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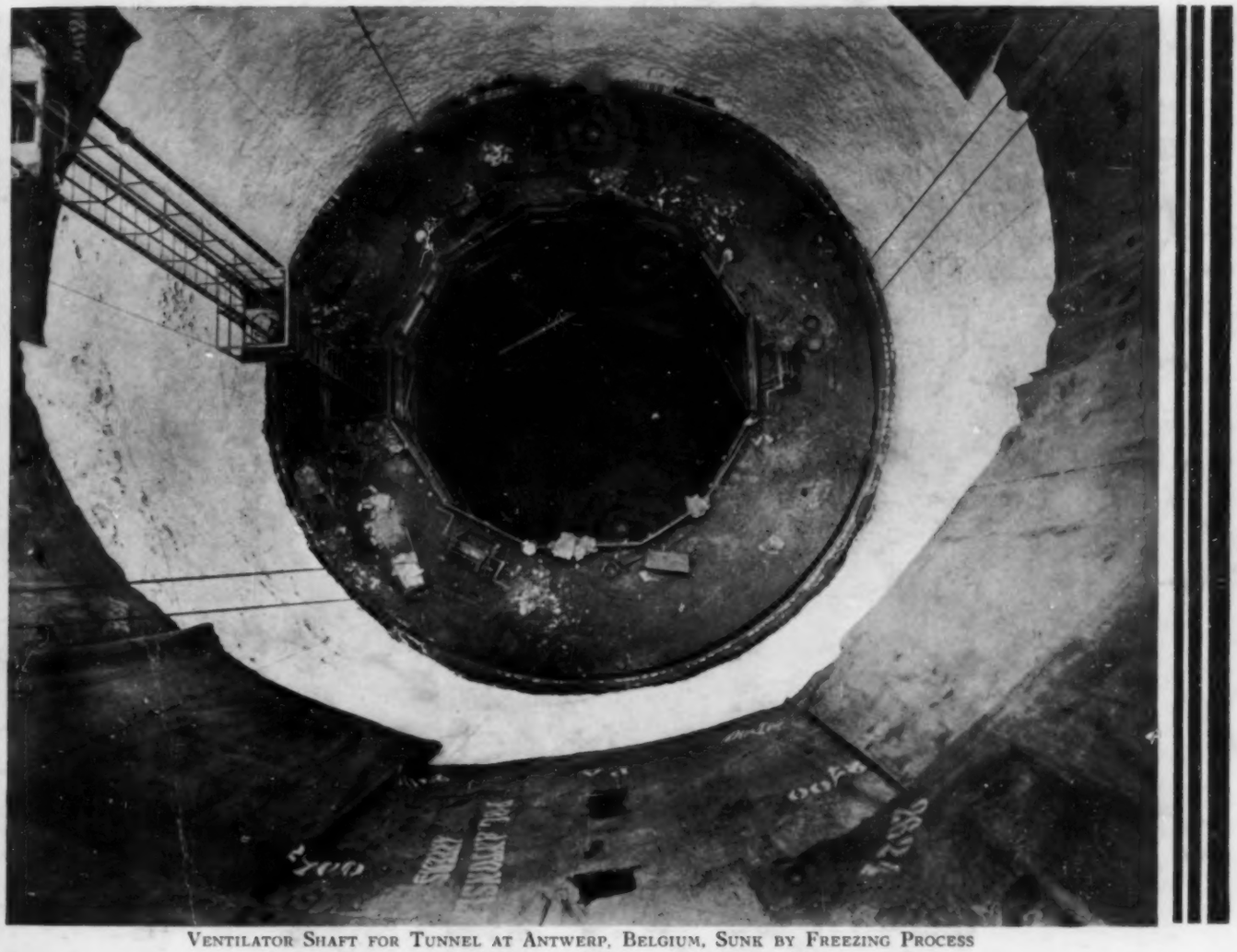
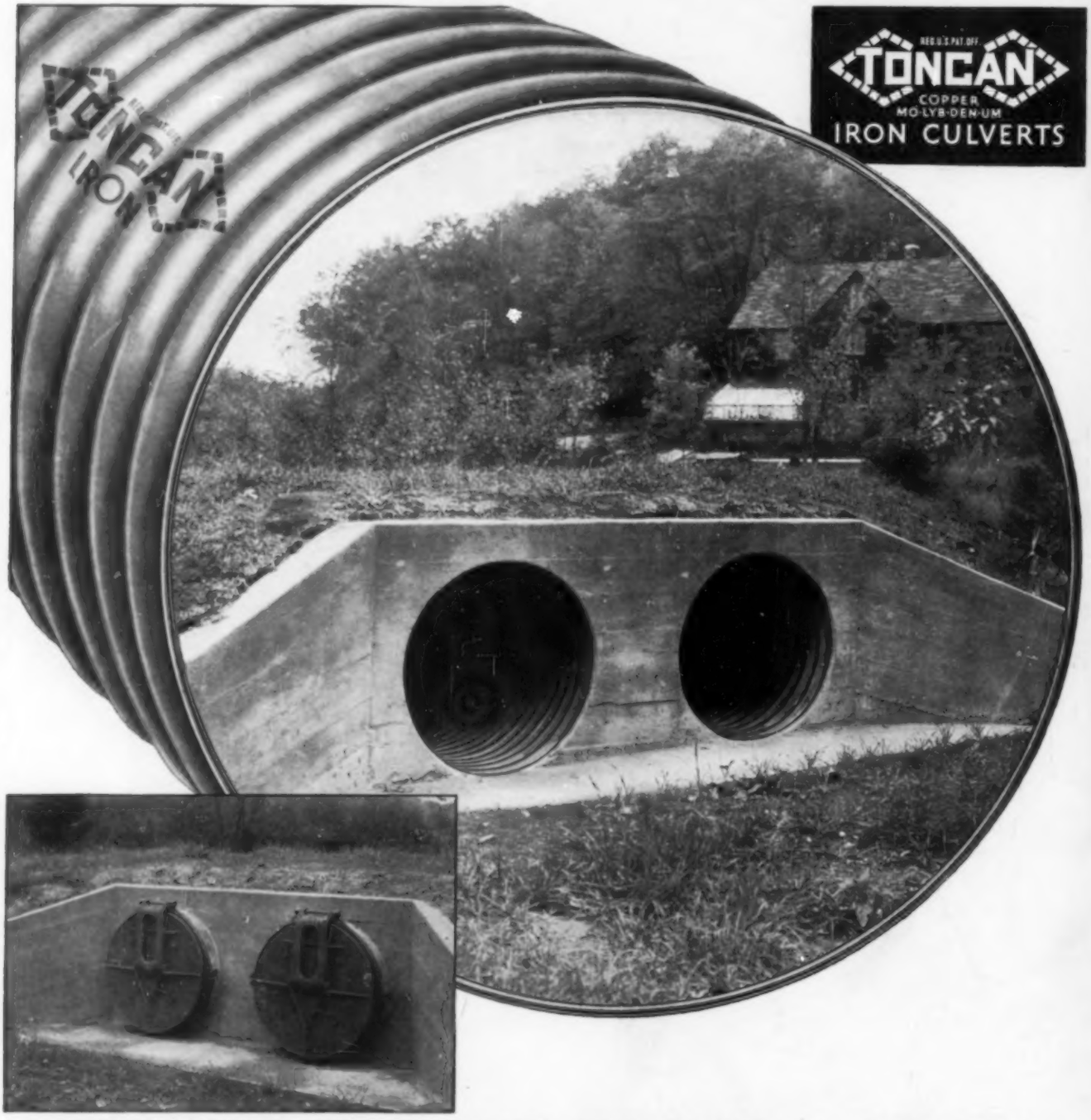


VENTILATOR SHAFT FOR TUNNEL AT ANTWERP, BELGIUM, SUNK BY FREEZING PROCESS
Unfrozen Ground Excavated Inside a Circular Ice Wall

Volume 4 — Number 1 —

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

JANUARY 1934



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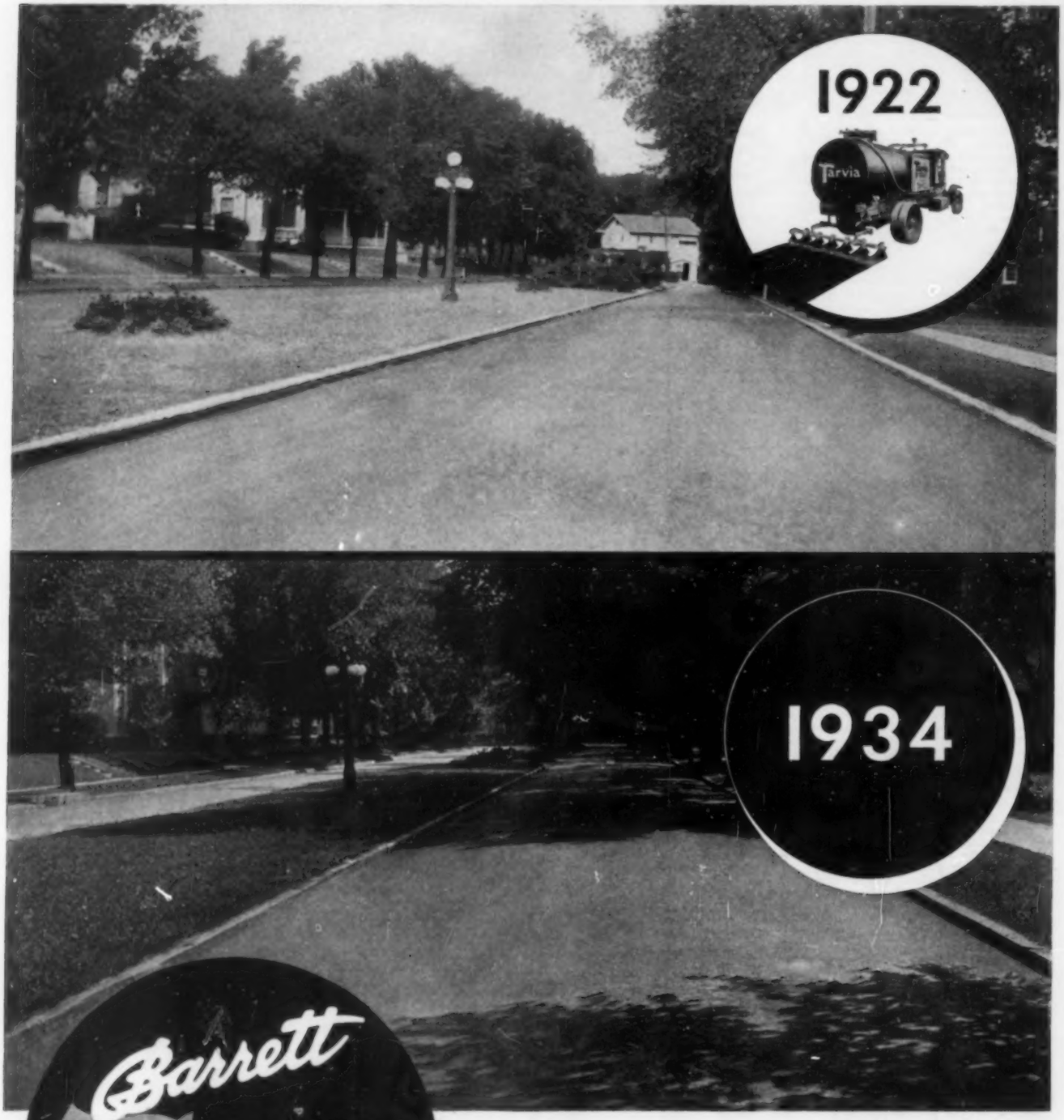

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JANUARY 1934

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VOLUME 4 NUMBER 1

Vehicular and Pedestrian Tunnels at Antwerp

Two Deep Bores Under the Scheldt River Recently Dedicated

By OLE SINGSTAD
MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
CONSULTING ENGINEER, NEW YORK, N.Y.

SEVERAL unusual features were incorporated in the design and construction of the two tunnels recently opened for traffic under the Scheldt River at Antwerp. Instead of combining the facilities in one large bore, two separate tunnels about a half mile apart were built, the northerly one for vehicles, the southerly one for pedestrians and bicyclists. Both were shield driven in the river section, but at exceptional depths below high water. In sinking the ventilator shafts for the vehicular tunnel and the entrance shafts for the pedestrian tunnel, the excavations were made within a solid circular wall of frozen ground. The ventilation system and a number of other features were patterned after those of the Holland Tunnel in New York. Tolls are charged, but amortization of the cost is to be hastened by the development as a residential suburb of the low land, formerly a military reservation, at the westerly terminals of the tunnels.

LOCATION PLAN

ON September 10, 1933, the two tunnels under the River Scheldt at Antwerp, one for vehicular traffic and the other for pedestrians and bicyclists, were opened to the public.

Antwerp, one of the world's principal seaports, is located on the east bank of the River Scheldt, which within the city limits flows in a northerly direction and makes a right-angle bend to the west on its 55-mile course to the North Sea (Fig. 1). The river separates the city, as well as the country to the east, from Flanders and the territory bordering on the North Sea. Until the completion of the tunnels, traffic on the main highway from Antwerp through Flanders to Ghent and the North Sea ports was dependent upon ferry transportation across the river. A heavy traffic of commuters from the smaller communities on the west bank also had been obliged to use the ferries to reach the city at the end of their railroad journey, since the terminal lies on the west bank. A considerable number of commuters travel by bicycle. The territory immediately adjoining the river on the west, consisting of the peninsula formed by the bend in the river, is almost entirely undeveloped. There has been for a number of years a military reservation on the west bank, surrounding a fortification which, now abandoned because of its nearness to the city, makes a large area immediately adjoining the city available for residential and commercial development.

Although the necessity for a fixed crossing had been apparent for many years, it was not until 1906 that legislation was enacted authorizing a government commission to investigate and report on the practicability of building a bridge across the river. In 1909 this commission reported its findings to the effect that navigation precluded the construction of a drawbridge or of any bridge requiring piers in the river or clear headroom less than 180 to 200 ft above mean high water. Because of the low level of the land and the nature of existing improvements on the Antwerp side, which would be in the way of a bridge approach, the commission concluded that the only practicable method for providing a fixed crossing of the river at Antwerp would be by tunnel. However, nothing was done toward materializing the project for a number of years, in large part because of the War.

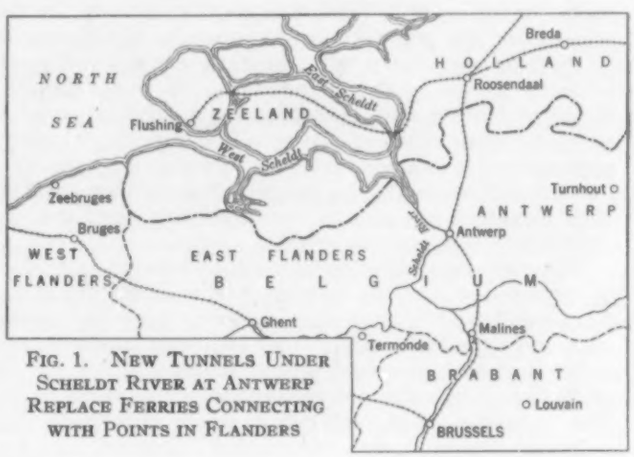


FIG. 1. NEW TUNNELS UNDER SCHELDT RIVER AT ANTWERP REPLACE FERRIES CONNECTING WITH POINTS IN FLANDERS

In 1929 the matter was again taken up, when by legislative action a commission was created for the purpose of building a tunnel. This was two years after the opening of the Holland Tunnel in New York, N.Y. It is believed that the striking success of that project, from engineering, traffic, and financial viewpoints, gave impetus to a movement for the early realization of the tunnel projects at Antwerp. This commission was authorized to issue bonds up to 500,000,000 fr, which were to be guaranteed by the Belgian Government to the extent of one-half the obligations, by the City and Province of Antwerp each to the extent of two-tenths, and by the Province of East Flanders, one-tenth.

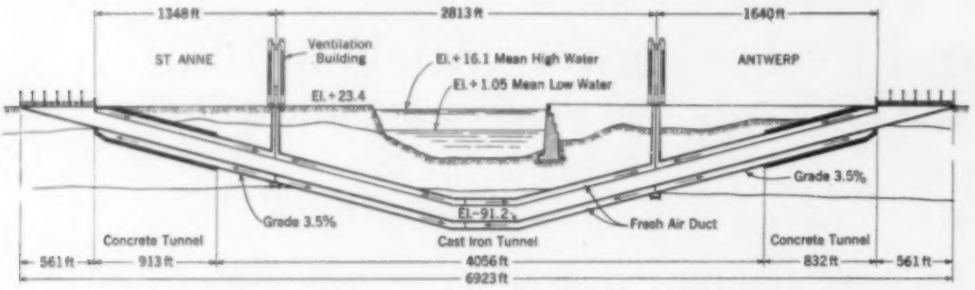


FIG. 2. PROFILE OF THE VEHICULAR TUNNEL UNDER THE SCHELDT AT ANTWERP

In addition, the Belgian Government donated to the commission the land comprised within the abandoned military reservation on the west bank. This land lies behind dikes along the river, and a large part of it is at a level below the river surface. The tunnel was planned as a toll project, but it was realized by the authorities that for many years the revenues from tolls would be insufficient to pay operating charges and amortize the capital investment. Its financial soundness, however, was assured by the government's turning over to the commission the vacant land, which it was planned to fill in to a proper elevation above the river for development as a modern residential suburb of Antwerp. It is from the sale of this land, as well as from tunnel tolls, that the cost will be amortized.

SIXTY COMPETITIVE PLANS SUBMITTED

By 1930 the commission was ready to proceed with the building of the tunnel. Following what appears to be the usual practice in Belgium as well as in other European countries where structures of unusual character and magnitude are involved, it advertised for competitive proposals which were to include plans, specifications, and the cost of constructing the entire project complete, ready for operation. Nine months were allowed for the preparation and submission of proposals, which were to be made in accordance with the outline plans and specifications issued by the commission. It was stipulated in the invitation that each proposal should incorporate at least two alternative plans: (1) a tunnel with ramp approaches for vehicles and with elevators near the river for pedestrians; and (2) a tunnel with ramp approaches, with elevators for pedestrians, and with auxiliary elevators near the river for vehicles.

There was no restriction as to type of design or method of contruction, and the invitation specifically requested proposals based upon designs differing from the outline plan and even based upon other locations, and also provided that each proposal should include a bid on the construction of a shield-driven tunnel with a metal lining. The invitation contemplated a single tube with two vehicular traffic lanes, one in each direction, and two sidewalks, each about 4 ft wide. The proposals were opened on September 15, 1930. They numbered more than 60 and were submitted by the leading contractors of Belgium, France, and Germany.

After four months' consideration, the commission awarded the contract to the Belgian firm, Compagnie Internationale des Pieux Armes Frankignoul (Pieux Franki), of Liége, whose plan was adjudged the most meritorious as well as involving the lowest bid price, amounting to about 250,000,000 fr. A contract was entered into based upon this sum, made up of unit prices applicable to the different items and containing a provision that the unit prices actually to be paid the contractor should include an adjustment of the bid prices up or down following the variations from month to month of the index number of commodities at Antwerp, the price of coal, and the market discount rate. This provision undoubtedly was introduced with the purpose of insuring equitable compensation to the contractor, but in view of the continuous decline in prices between the dates of submission of the bids and the completion of the work, it is questionable whether the intended result was fully attained. Since a contractor must order his materials at agreed prices perhaps months before they will be placed in the structure, there may be a considerable drop in commodity prices during the interval before he is paid for them.

In certain important respects the adopted plan differed from the outline plan, which combined in a single tube facilities for both pedestrian and vehicular traffic. Because the most useful location for a pedestrian crossing did not coincide with any of the streets on the Antwerp side suitable and available for adequate approaches to the vehicular tunnel, the outline plan called for a river crossing at the desirable location for pedestrian traffic, with elevator shafts near the river bank to take care of such traffic. According to the outline plan, the tunnel would then continue along the water front in a northerly direction and turn under a wide street about one-half mile north of the river crossing, where suitable approach facilities for vehicles could be provided. The outline plan showed a roadway width of 20 ft with a 3 per cent approach grade.

Pedestrian and vehicular traffic were separated in the adopted plan, which provided two tunnels, a small one for pedestrians and bicyclists at the location best suited for this class of traffic, with elevator and escalator shafts for access and egress near the river banks; and a vehicular tunnel located at the point where adequate approach facilities could be most conveniently and economically provided. This arrangement, in addition to affording the greatest facility for each class of traffic and giving an almost straight alignment, has operating advantages. Also, in the case of the vehicular tunnel it resulted in a considerable saving in the cost of construction due to a shortening of the tunnel under the river and a material reduction in its diameter. A shield-driven tunnel of the size required for two lanes of vehicular traffic and two wide sidewalks would have been considerably larger than any similar work carried out in soft ground and would have involved greater construction difficulties and ex-

pense. Operating experience with other tunnels has indicated that the 22-ft roadway adopted is preferable to a 20-ft width where two lines of traffic move in opposite directions, and that the $3^1/_2$ per cent grade chosen for the approaches gives entirely satisfactory operating conditions, with a material saving in cost of construction as compared with a tunnel having a 3 per cent approach grade. A profile of the vehicular tunnel is shown in Fig. 2.

It is to be noted that of the more than 60 proposals submitted, none was based on the trench method of construction. After an examination of the conditions at the site, this is readily understood in spite of the success with which this method has been applied to the construction of subaqueous tunnels where local conditions were favorable to its use. On the west bank of the Scheldt, conditions were quite favorable to the use of the trench method; the ground was low in elevation, practically unused, and of such character that it would stand up on a reasonable slope in a dredged trench. In the river and on the east bank in Antwerp proper, however, conditions were such as to make this method impracticable. The river carries a great volume of shipping, much of which consists of large ocean-going vessels. The current is swift, as might be inferred from the 15-ft mean tidal range. On the right bank there is a masonry quay wall 56 ft high. The tunnel is necessarily located at great depth on account of the requirements of navigation and the great range between high and low tide. Each side of Canal de l'Ancre, the Antwerp street under which the tunnel is routed, is occupied by a solid row of buildings, which would be within range of disturbances caused by the construction of a trench. Also, movement of traffic on the marginal street would be seriously interfered with if the trench method of construction were used.

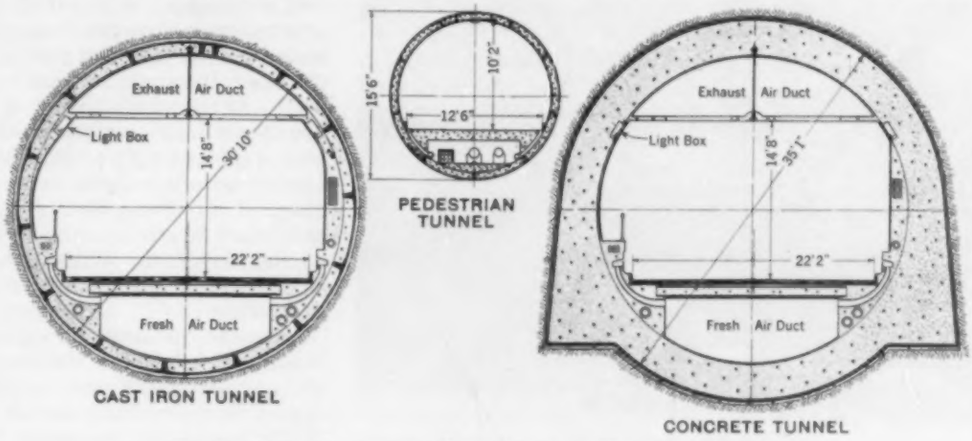


FIG. 3. CROSS SECTIONS OF PEDESTRIAN AND VEHICULAR TUNNELS Under the Scheldt River, Antwerp

MATERIALS PENETRATED

Along the approaches to the tunnel from both sides of the river the streets and the ground are at elevations of 7 ft or less above high water. The underlying material consists of a firm clay with a nearly level and quite regular surface at a depth of about 85 ft below high water. Overlying this firm clay is a thick bed of sand of very fine grain in the lower part of the stratum, ranging in places to a coarse sand in the upper part. Especially on the west bank and extending partly under the river, the sand is covered by an impervious layer of turf and clay of variable thickness. The bottom of this stratum is about 40 ft above the bed of firm clay. Overlying the turf on the west bank and the sand on the east, and extending to the surface, is made ground consisting of miscellaneous materials. This layer is above the tunnel level except at the open approaches and for a few hundred feet inside the portals on each side of the river, where the top of the tunnel rises into this made ground. The shield method of construction was clearly indicated as the one best adapted to these conditions.

Navigation requirements called for a depth of 45 ft of water at low tide. This, coupled with the necessary cover over the tunnel to protect it from damage by sunken vessels, and the range of the tides, required that it be placed at an unusually great depth below high water. It was also found that when thus located the top of the tunnel would be at about the line of demarcation between the firm clay and the overlying sand. In consideration of the much greater safety in tunneling operations and the reduced air pressures required if the top of the tunnel were placed several feet below the top of the impervious clay, it was decided to lower the profile under the river bed so as to take advantage of the protection thus afforded. As a result, the bottom of the vehicular tunnel was placed 116 ft below high water, and the roadway 107 ft below high water. This is 14 ft deeper than the roadway of the Holland Tunnel under the Hudson River.

As shown in Fig. 2, the vehicular tunnel is 5,801 ft long between portals and 6,923 ft long between street grades. The shield-driven section is 4,051 ft long and has a cast-iron lining 30 ft 10 in. in outside diameter, and similar in design to the lining of the Holland Tunnel.

No other shield-driven subaqueous tunnel of large diameter built in soft ground is as deep as this vehicular tunnel. The roadway is 22 ft 2 in. wide (Fig. 3), adequate for high-speed operation of two lines of traffic in opposite directions. It has a service walk about 2 ft wide on one side of the roadway. On the open approaches the roadway is wide enough for three lanes, two of them for use by the exit traffic.

LOWERING THE GROUND WATER

Work was started on the west side of the river, where about 1,460 lin ft of approach ramp and tunnel was constructed in open cut. A lift extending down about 23 ft at its deepest part was excavated with sloping sides. At this lower elevation an impervious stratum of turf permitted the use of surface drains leading to a sump, from which, with the assistance of well points set back from the cut on both sides and connected to a pumping plant, the water seeping through the sandy upper banks could be pumped into the river. A second lift was then started, also with sloping sides, leaving a bench or berm at the turf layer. For unwatering this second lift, which carried the excavation down to about the 46-ft depth, and the final cut, which was confined by steel sheet piling, a number of wells were driven down to the massive clay bed, lying about 92 ft below the ground surface. Submerged electric pumps in these wells, which were placed

at intervals of 15 to 60 ft, lowered the ground water successfully. In sinking these wells, a 20-in. casing was first driven; then a 10-in. pipe was inserted, with coarse and fine screens at its lower end. Next the annular space between the two pipes was filled with sand and pea gravel, after which the outer casing was withdrawn. A self-contained electric pump, driven by a 5-hp motor

CONCRETE TUNNEL SECTION UNDER CONSTRUCTION IN OPEN CUT
West End of the Vehicular Tunnel, Antwerp

and having a capacity of 4,500 gal per hr, was lowered into the 10-in. tube.

The west portal was located at the end of 561 ft of open approach, from which point 900 ft of tunnel was built in the open cut. This part consisted of a reinforced concrete structure (Figs. 2 and 3) of essentially circular section, similar in interior form and detail to the shield tunnel. While this reinforced concrete work was under construction, a tunnel shield was assembled at its easterly end, in the open cut, and upon completion of the concrete two or three cast-iron rings were erected, bringing the structure to the tail of the shield, ready to start the tunneling proper.

The layer of impervious turf, previously mentioned, extended for some 300 ft beyond the west bank, toward mid-river. By sinking a row of wells roughly 50 ft on each side of the tunnel line, and pumping them in connection with those on the bank, the ground-water level was kept down to such an extent as to reduce materially the necessary air pressure behind the shield as it proceeded under the river. For the first six weeks the tunneling was conducted without the use of compressed air in the heading. Sixty rings were erected. A bulkhead with man and material locks was then constructed and the shield advanced through the west ventilation shaft and under the river. A second and last bulkhead was built 2,000 ft farther along.

AIR PRESSURE IN TUNNEL

Although the theoretical hydrostatic head at the tunnel invert in mid-river is about 49 lb per sq in., the maximum air pressure in the heading was only 34 lb, and in general only 18 to 20 lb was found necessary. These low pressures were in part due to the lowering of the ground water and in part to the solid clay in which the deeper part of the tunnel was located.

On the east or Antwerp side of the river, the design incorporated an open approach ramp and a reinforced concrete section of about the same length as that described for the west side, and of similar type. Construction proceeded as on the west side, with ground water lowered in the same way, except that the trench was sheeted for the full depth.

For the vehicular tunnel two ventilation shafts, one on each side of the river, were sunk by a method seldom practiced in the United States. The reinforced concrete shafts are rectangular in plan, 53 by 56 ft, and rest on the clay bed 85 ft below high water. Instead of sinking these as caissons, the contractor first drove 116 wells in two concentric circles, respectively 78 and 86 ft in diameter, enclosing each shaft site. The 6-in. casings were sealed in the massive clay. In each well a 2-in. pipe was then inserted, with its open end almost at the bottom. At the top, the 2-in. and the 6-in. pipes were connected into ring manifolds, forming, in conjunction with a refrigerating plant, a closed system through which low-temperature brine was circulated for a period of about 4 months. Thus solid circular walls of ice and sand were frozen some 10 to 15 ft thick, extending down to the clay bed. Within this protecting shell the unfrozen ground was excavated without the use of sheeting or bracing.

Circular openings on opposite sides of the concrete shafts were left for the passage of the tunnel shield. Temporarily these were closed by wooden bulkheads, and spaces between shafts and ice walls backfilled with clay. While advancing the shield through the ice wall of the west shaft, the annular space between the iron lining and the tail of the shield was stuffed with rolls of burlap previous to each shove. These were prevented from moving with the shield by steel rings which the shield jacks held in place against the face of the last-erected lining. After each shove the space around the lining was grouted, forming an effective seal against inflow of water. No compressed air was used, nor was the shaft roofed over. Erection of the cast-iron tube was continued right through the shaft, and the rings were not removed until the second bulkhead was built. Compressed air was necessary in tunneling under the river and on the up grade through the east shaft. To permit driving through the east shaft, the air ducts and passages leading up to the surface were closed with concrete bulkheads weighted with earth. A man-lock was installed in the vertical wall of the east shaft.

Erection of the shield in the open cut on the west bank started on August 1, 1931; the first shove was made on November 9, 1931. On February 29, 1933, the tunnel was holed through. The progress of the shield averaged 10 ft per day (24 hr) and reached a maximum of 9 rings, or 22.5 ft, per day. Working hours in compressed air and time for decompression were regulated substantially in agreement with the statutory requirements effective in New York, N.Y.

Cast-iron rings 30 in. long, with a minimum web thickness of $1^3/_4$ in., form the lining of the vehicular tunnel. Each ring is composed of 14 segments and a key. Flange depth is 14 in. and bolt diameter, $1^3/_4$ in.

Segmental cast-iron rings line the pedestrian tunnel, 1,750 ft long, between the construction shafts in which the passenger elevators are housed. It is a shield-driven structure 15 ft 6 in. in outside diameter, with a walkway 12 ft 6 in. wide. It was located entirely in the massive clay, with 10 ft of clay cover and was built without the use of compressed air, although provision was made for this if it should be found necessary during the progress of the work. The driving of this tunnel presented no unusual problems, but the construction of the two terminal shafts and escalator galleries was of interest in that there again the use of ice walls in place of caissons and sheeting was found economical. At each end the escalators are designed in two lifts, with a circular intermediate

landing set back inland from the main shaft. This necessitated driving one shaft of full depth at each terminal and a second one of half depth. The principal shafts are 38 ft in inside diameter and 120 ft deep. Freezing wells were driven from 3 to 4 ft apart to enclose these circular shafts, and three additional lines were driven to form straight walls between the shafts. This permitted excavation for the runs of escalator from shaft to shaft. At each terminal 145 wells were sunk.

In both tunnels the walls are lined with vitrified tile, which in the case of the pedestrian tube extends to a height of about 6 ft. Above this height the ceiling, following the circular tunnel outline, is of concrete and is painted. The vehicular tunnel ceiling is made of preformed concrete slabs supported on the side walls and at the middle line of the tunnel, where a pair of longitudinal angles are suspended by hangers from the cast-iron lining. The roadway of the vehicular tunnel is paved with granite blocks with mastic joint filler.

Ventilation of the vehicular tunnel is by the transverse distribution method developed for the Holland Tunnel and later adopted for the Detroit–Canada and Oakland–Alameda tunnels. The structure is divided into four ventilation sections, served by one building on each side of the river. Three blower and three exhaust fans on each section make up the total installation of 24 fans.

Although a limited volume of normal traffic is expected for a considerable period of years, it was recognized that ample ventilation should be available in case of emergencies, such as fires, and for periods of unusually heavy traffic. To take care of capacity requirements the design provides for the operation of all fans at full speed, but for the normal condition of greatly reduced air volume economical consumption of power is secured by a novel arrangement which incorporates two motors on the same shaft, for each fan. For the minimum ventilation requirements, when only one fan at low speed is needed on each duct, the smaller of the two motors is adequate; but for full speed and power, the larger motors on all three fans are cut in. The possible combinations of these motors permit economy in power use for intermediate air requirements. Fans are carried on roller bearings and have "tex rope" drives. Automatic carbon monoxide recorders and a supervisory control board were installed in the ventilation building on the east bank.

With one striking exception the interior is very similar to that of the Holland Tunnel. Bright yellow lighting is furnished by sodium vapor lamps, installed in boxes recessed in the walls just below the ceiling, with opal diffusing glass covers. The consumption of current for equivalent illumination is much less than with tungsten lamps.

In accordance with the terms of the invitation and contract a time limit for completion of the work was set by the bidder, with the provision of a bonus or a penalty for completion of the vehicular tunnel before or after 1,000 working days from March 1, 1931; and for the pedestrian tunnel, 700 days from July 1, 1931. The work was finished nearly a year ahead of time, earning the contractor a substantial bonus.

The opening of the tunnels was marked by elaborate ceremonies, attended by King Albert and the royal family, the United States Ambassador, many other notables, and an immense crowd from all over Belgium, who made September 10, 1933, a fête day.

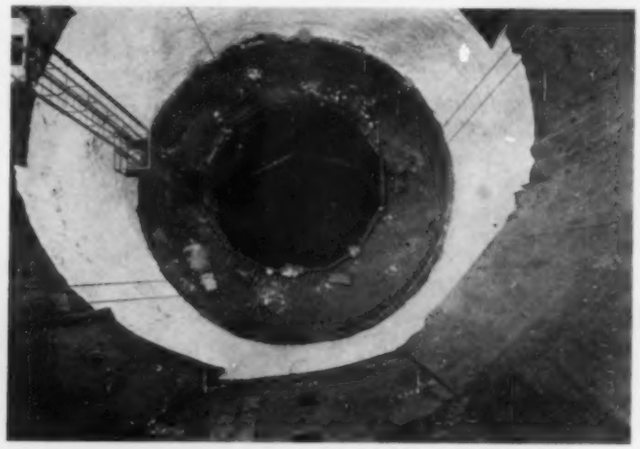
TABLE I. TRAFFIC COUNTS DURING FIRST THREE WEEKS

TYPE OF TRAFFIC	WEEK ENDING		
	Sept. 16	Sept. 23	Sept. 30
Vehicles	16,811	15,919	13,736
Pedestrians	168,735	179,071	130,754
Bicyclists	12,155	15,743	15,559

Widespread interest in the project was attested by the traffic of the opening day, which for several hours taxed the capacity of both tunnels. Their continuing popularity is indicated by the counts of the first three weeks, given in Table I. Toll rates for passenger cars are 10 fr; for pedestrians, 0.5 fr; for bicyclists, 1 fr. The facilities are open day and night.

A governmental corporation, Intercommunale Maatschappij van den Linker Schelde-oever, of which Baron Holvoet, Governor of the Province of Antwerp, is Chairman, and F. P. Thonet, Chief Engineer, was the agency through which the tunnels were constructed. The entire work was designed and executed by the contracting firm of Pieux Franki, of which Edgard Frankignoul is President; Albert Dewandre, Engineer Director; and Paul van Hauwaert, Chief Engineer. A. Maistriau was in general charge of construction for the contractor, and Harry Talbot was superintendent in charge of shield tunnel work on the large tube.

Parsons, Klapp, Brinckerhoff and Douglas of New York, M. G. Henry of Paris, and the writer were consulting engineers to the contractor in the preparation of plans and proposals and execution of the work. G. P. Nijhoff of The Hague was consultant on lowering of ground water.



FREEZING PROCESS USED IN SINKING VENTILATOR SHAFTS
At Left, Freezing the Ground Around the Shaft; at Right, Looking Down Into the Shaft During Sinking

A Pioneer Suspension Bridge in Colombia

Record Span for South America, Built in 1894, a Product of Local Genius

By F. R. MOLTHER

MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS

ARCHITECT, QUARTERMASTER CORPS, U.S. ARMY, QUARRY HEIGHTS, CANAL ZONE

IN 1894 the longest suspension bridge in South America, of 940-ft span, was completed over the Cauca River, in Colombia. At that time it was also the fourth longest of its type in the world. In 1893, while Col. W. F. Shunk was making his famous survey for the Pan-American Railway from Ecuador to Costa Rica, he saw the Cauca River bridge and a similar structure upstream near Jerico (Fig. 1). Of these two structures he wrote in his report:

> Having regard to their secluded location and the difficulties to be overcome, both physical and financial, these structures are grander undertakings than the Brooklyn Bridge was to its builders. They honorably illustrate the intelligence and energy of the *Antioqueños*.

ALTHOUGH remarkable in many particulars, the great Puente del Occidente, "Bridge of the West," is little known, at least in North America. When built, its span of 940 ft gave it rank as the fourth longest suspension structure in existence. Even more notable are the conditions under which it had to be erected in the then remote interior of Colombia, accessible only by pack train. As here so vividly described, this bridge is a monument to a single engineer, Dr. José Maria Villa. His was the vision, his the artistry; no one else even knew his plans, for they were invisible, existing only in his own fertile brain. Technical men will thank Mr. Molther for his careful research in unearthing the astounding history of this unique engineering structure.

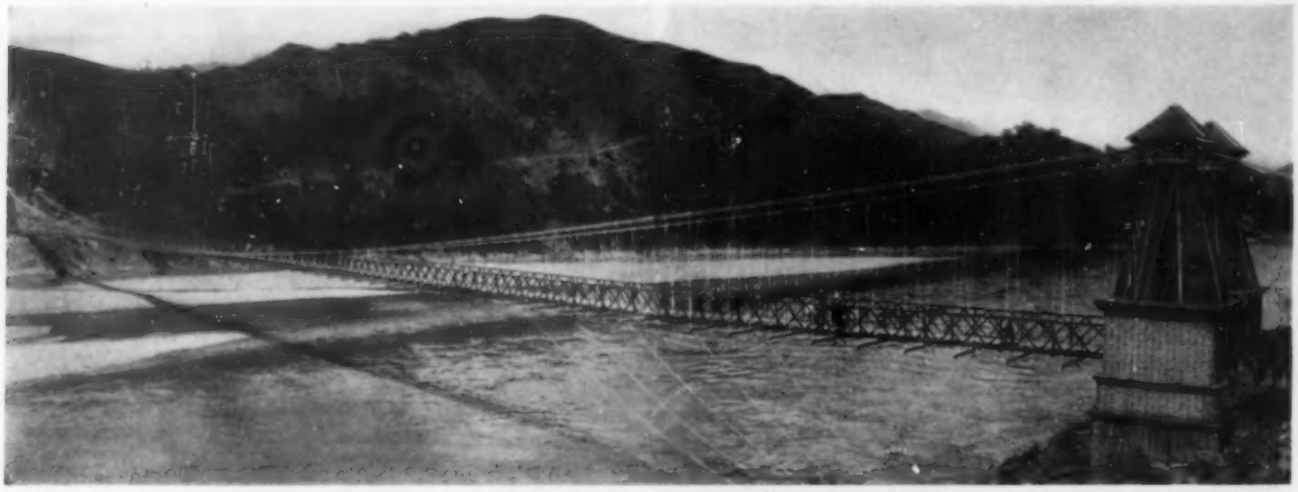
A citizen of Colombia, José Maria Villa, was the designer and erector of the Cauca River bridge, called the *Puente del Occidente* ("Bridge of the West"). He was born in October 1850, in the nearby city of Sopetran. When 14 years old, Villa made the three-day trip from Sopetran to Medellin, the capital of the Department of Antioquia, for the purpose of matriculating in the state university. Here the youth's talent for mathematics became promptly apparent, and also his strong individuality and independence of action. His publication of a satirical article exaggerating some of the deficiencies of the university was immediately followed by his expulsion. Doubtless to the future benefit of his country, although somewhat prejudicial to the discipline of the institution, this action was rescinded by the then president of the state, Dr. Berrio.

In 1876 the government of Antioquia dedicated a small part of its budget to the extension of Villa's education in the United States, with the result that the 26-year-old student matriculated at Stevens Institute, in the College of Mechanical Engineering. After graduation, Villa worked for a brief period on the construction of the Brooklyn Bridge before returning to his native country and department in 1879. The influence of his training and experience in foreign fields became immediately apparent when he undertook his first important work in his native country, the *Puente del Pescadero* ("Fishmonger's Bridge"). On this structure, which replaced canoe ferries across the Cauca River, on the road between Ituango and Yarumal (Fig. 1), suspension cables were employed for the first time in Colombia.

The Jerico Bridge (Fig. 1) which next claimed Villa's attention, has a deck 24 m above the water and consists of two suspension spans that total 92 m (302 ft) in length. In the *Puente Pintado* ("Painted Bridge"), his last effort before he undertook his masterpiece, the Puente del Occidente, Villa first developed wooden towers to take the place of masonry supports.

VILLA SELECTED TO STUDY PROJECT

Before the construction of the Puente del Occidente, communication between the northwest and southeast parts of the Department of Antioquia, divided by the Cauca River, had been provided by intermittent ferry service. These two divisions of the department are



GENERAL VIEW OF THE PUENTE DEL OCCIDENTE, LOOKING DOWNSTREAM

6

about equal in population; in 1918 each contained 45,000 people. The division toward the north, to which the bridge gave a means of access to markets in the interior of the country, is chiefly a tobacco and coffee producing region.

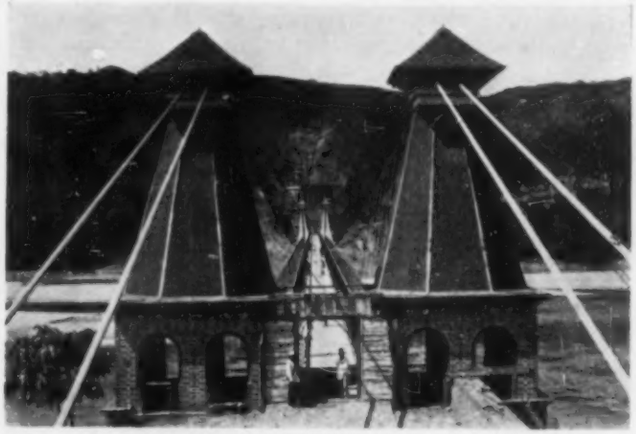
Early in 1886, the government of the Department of Antioquia contracted with Dr. Villa for the examination of possible sites for a bridge across the Cauca to connect the towns of Sopetran and Antioquia (Fig. 1). Local tradition holds that he made this examination by swimming down the stream, receiving enthusiastic welcomes in all the towns which might be affected by the construction of the proposed bridge. The advantage of swimming over making the trip by canoe is not apparent; but the story is consistent with the eccentric nature of the man, who could, according to another anecdote, enter his neighbor's house, divest himself of his clothes, and retire to bed in the conviction that he was in his own home. When awakened by the lady of the house, the story goes that Villa apologized for his mistake, dressed calmly, and went home.

As a site, he recommended Quebrada Seca, where the river flows between two headlands that are suitable for bridge abutments. In addition, since they are parts of ridges on each side of the river, these headlands confine the current to a definite and fixed course. Their position suggested to Villa that the stream had cut through a dike and that a suitable foundation for a pier might be found in the center of the river. High water prevented soundings, but local reports claimed that bars appeared in the stream at lower stages. Incidentally, as is frequently the case when local informants give data in accordance with their interest and desire, this assumption proved ungrounded, so that the bridge had to be built in one long, single span.

Further, the report included recommendations for the specifications of the proposed bridge and called attention to the high cost and delay involved in the use of imported materials. In the epoch under consideration, such purchases probably required a minimum of eight months for transit from New York to the bridge site under the most favorable conditions. They were moved by ship from the United States; by river steamer on the Magdalena River; over the small part of the Antioquia Railway then in service from Puerto Berrio; and then by pack trail, via Medellin, to Sopetran and to the site. Even today, with greatly improved conditions of transport, the minimum time required with the best of connections is about three months, and this frequently is lengthened to six or eight months. Villa's recommendations as to the use of wood and brick in certain places where ordinarily steel or iron would have been preferred, were therefore particularly applicable.

Probably the chief characteristic of suspension bridges which influenced Dr. Villa in recommending this type was their economy. The suspension bridge becomes increasingly economical, in comparison with other types, as the live load of moving persons, animals, and vehicles becomes lighter in proportion to the dead load of the structure.

Besides its economy, the suspension bridge has many other points of superiority. It is light, graceful, and



END VIEW OF THE "BRIDGE OF THE WEST," LOOKING TOWARD THE CITY OF ANTIOQUIA

pleasing to the eye; it makes possible a low elevation for the roadway, and it has a low center of wind pressure. Moreover, it requires no falsework; it can be constructed of materials that are readily transported; and there is no danger of failure during erection. Villa mentioned the availability of lumber of suitable character nearby, in Liborina, and of lime from a plant in Sucre. He also noted that laborers and artisans for the work could be secured from numerous small towns in the vicinity. He estimated the cost at $80,000 to $100,000. Since the income from the ferries at Paso Real and Sacaojal amounted to only 5,000 pesos annually, which would allow only 5 per cent on the investment, he recommended assistance from the government.

A contract dated May 12, 1887, granted exclusively to the promotors the right to construct and exploit a steel suspension bridge for a term of 80 years after completion and required the transfer of the structure, in satisfactory condition, to the departmental government at the end of that period. Construction was to start within one year, and the bridge was to be opened to service four years from the start of construction activities. The zone of privilege, within which no other permission to cross the river by bridge, ferry, boat, canoe, or other means might be granted, was one miriametro (6.28 miles) above and one below the site selected.

Tolls were fixed at 5 centavos (1 peso = 100 centavos = $0.973, par value) for each person, pig, sheep, or other small animal; 10 centavos for each mule, horse, or

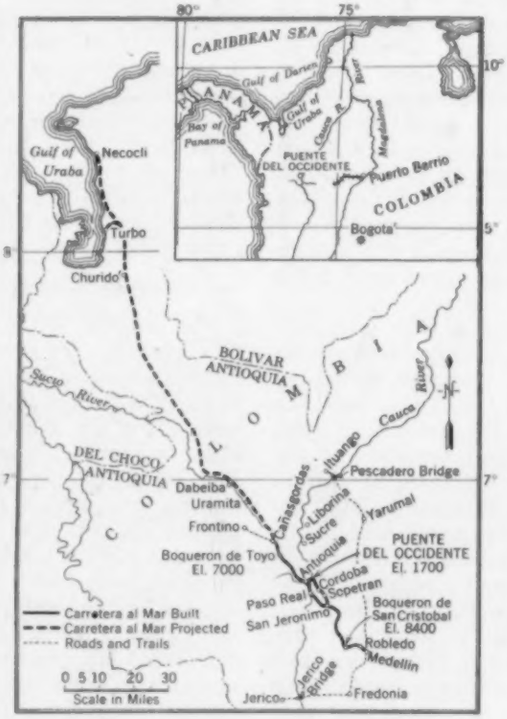


FIG. 1. GEOGRAPHIC POSITION OF THE PUENTE DEL OCCIDENTE IN THE REPUBLIC OF COLOMBIA

Some authorities give the theoretically economic sag ... arriving at the site too early. When he and a couple of

steer; and an additional 10 centavos for each of these animals if it carried a pack. The document was approved by the President of the Republic of Colombia, the Honorable M. A. Caro, on September 27, 1887. Decree No. 89 of that year granted 10,000 hectares of government land to be awarded to the contractors on the completion of the bridge.

In order to start construction, it was necessary to build trails to the site, not for vehicular traffic but for pack trains. As one of the old workmen explained to me, "It may be said that the bridge was built without the use of wheels." All the materials for construction and other supplies were brought in on the backs of mules, horses, and oxen.

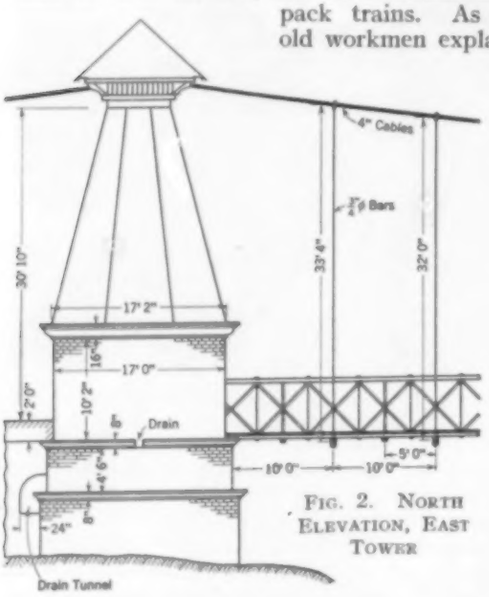


FIG. 2. NORTH ELEVATION, EAST TOWER

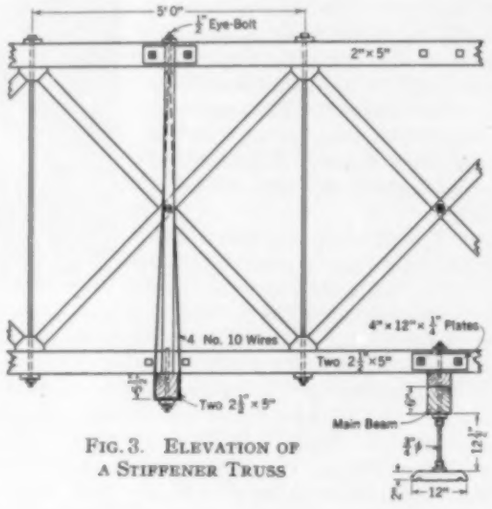


FIG. 3. ELEVATION OF A STIFFENER TRUSS

A farm on the Antioquia side of the bridge was assigned to the artisans and workmen. Bunks were built and numbered in accordance with the systematic plan of organization which Dr. Villa seems to have insisted upon in all his work, except as regards those features which related to him personally. For instance, drawings of the design of the bridge were never made, except for certain details which are reported to have been given graphic form on the whitewashed *tapia* ("rammed earth") walls of the cantina where José Maria might have been drinking *aguardiente* when a foreman asked for instructions, or on the bare plank walls of the common dining room, where a discussion might have come up after supper.

Discipline in the camp grew out of the congenial atmosphere that prevailed, fostered by the unpretentious manners of the genius at its head. The men remember Mrs. Villa as a simple, unaffected lady, who took her meals at the general mess table. Life in the quarters was so congenial, I was assured, that very few of the workmen left camp on Sundays or holidays, in spite of the proximity of several towns, with their holiday attractions of cantinas, markets, and promenades. Then too, *aguardiente*, that powerful intoxicant distilled from sugar cane, so generally popular throughout Latin America, was available at the camp although the use or presence of a supply at the site of the work was prohibited. Under the inspiration of Dr. Villa, a violinist of ability, an orchestra was informally organized, which entertained the men every night. An important part of the entertainment was provided by a particularly capable guitarist, who was so competent among a people whose favorite and most familiar instrument is the guitar, that his name, Robledo, is still remembered.

Another playful eccentricity of Dr. Villa was shown at the camp, where any of the workmen might awaken to find some part, or all, of his working clothes missing. In response to loud-voiced protests, one of the first to approach the indignant and unclothed individual would be Dr. Villa, wearing the missing garments on his own person.

During the construction of the bridge only one serious accident occurred, when a workman engaged in laying the floor planks was killed by a fall to the beach. This is a remarkable record, particularly in view of the lack of experience of the local artisans in work of this character.

On the east or Sopetran side, nearest to Liborina, the source of the lumber, were located the shops and stores of materials. Here were employed the 200 carpenters, blacksmiths, and laborers engaged in the production and assembly of the elements that made up the great "Bridge of the West." All details were designed in the mind of the master engineer, who scorned to make drawings explaining his requirements. During the course of the work, timid spirits, awed by the boldness of the plan, fostered propaganda for the removal of Dr. Villa. Ever-present rumors, which no pioneer enterprise lacks, anent José Maria's fondness for the bottle and general eccentricity of character, were sufficient to induce the directors of the company to visit the site of the work for the purpose of removing him from his post. Observing that many features of the construction had not yet been determined, they asked the engineer for his plans. "Here they are," he exclaimed, striking his forehead, where indeed the only designs for the completion of the work existed. So the idea of removing Dr. Villa from the scene of his efforts was never executed.

VILLA DEFENDS HIS PLANS AND JUDGMENT

Fortunately for the amplification of the scanty records now available for even the most persevering research, a mining engineer named Francisco Escobar visited the site of the bridge during its construction and wrote an article for an American engineering journal on his observations. A copy eventually found its way to Dr. Villa and profoundly displeased him, apparently because the author damned him with faint praise and offered his comments in a foreign publication. In rebuttal, Dr. Villa published, in September 1895, a booklet in which he not only revised many statements regarding dimensions, weights, and stresses made by his critic, but, what is more important, gave his own analyses of calculated stresses and explained the theories that provoked the departures from usual practice which had caused Dr. Escobar to call the bridge "the weakest and yet most rigid of its type, a bold feat of engineering and a daring departure from principle and practice."

Some authorities give the theoretically economic sag ratio for the cables of suspension bridges as 1:6. Ratios of 1:8 or 1:12 are more generally adopted, however, as they produce more pleasing lines and increase the lateral and vertical rigidity. For the Puente del Occidente Dr. Villa adopted a sag ratio of about 1:27—for the purpose of reducing the wind stresses, he explained. Because of these reduced wind stresses and dead loads, less resistance was required in the towers and anchorages, structures which, in their position and dimensions, were rigidly limited by the topography of the site.

The depth ratio of the stiffener trusses is about 1:143, which is also unusual. The distance from center to center of the stiffening trusses is given by some authorities as preferably $^1/_{24}$ of the span, but that employed by Dr. Villa is $^1/_{32}$ of the span. These unusual proportions are justified by the exceeding lightness of the live loads in comparison with the dead loads, for this structure was designed for nothing heavier than pack trains or cattle. Moreover, these dimensions were compensated for by groups of sway bracing and stiffening cables extending to the towers and to independent masonry anchorages on the banks.

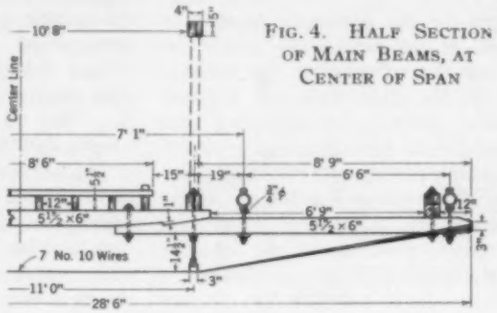


FIG. 4. HALF SECTION OF MAIN BEAMS, AT CENTER OF SPAN

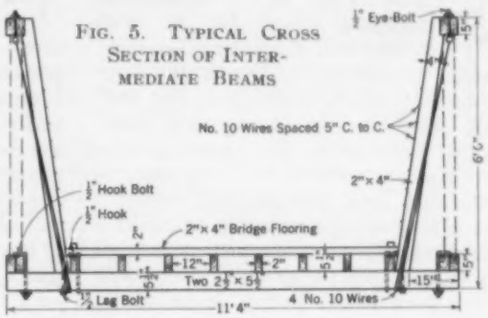


FIG. 5. TYPICAL CROSS SECTION OF INTERMEDIATE BEAMS

Probably the limitations surrounding the local manufacture of iron parts dictated the use of fixed seats for the cables, although the scrupulous maintenance required for movable cables may have influenced Dr. Villa's choice in this regard. Such maintenance is often difficult to obtain for isolated structures, a fact of which he may well have been cognizant. Obviously, the use of fixed seats introduced moments in the towers that would have been avoided by movable cables, but this stress was disposed of by Dr. Villa by the use of a wooden tower structure.

Transportation methods limited the size of the timbers that could be brought to the site and required an ingenious use of short pieces of modest cross section, as demonstrated in the details shown in Figs. 2–5. The employment of iron members or of wrought-iron connections could be anything but generous owing to the scarcity of this material, its high cost, and the delays incident to its transportation. Hence roble, a local variety of hard oak, was chosen for many fittings that under other conditions might have been made of cast-iron.

Finally, Dr. Villa's analysis demonstrated a theoretical capacity for his bridge of 95 tons more than the weight of the structure, which he calculated at 160 tons. The live-load capacity he translated into layman's terms as "320 of our fat cattle, or 1,200 of our soldiers with complete field and battle equipment."

Even on the day of inauguration, after six years of work on the bridge, there were still certain suspicious souls who doubted the supporting ability of the structure. As one feature of the ceremony, which was held in July 1894, a large number of cattle were driven across the bridge before the visiting government and church officials, the committee of inauguration, and the spectators trusted themselves to its sturdy strength.

One workman, who had been associated during the later years of construction in no less important a department than that of cable spinning, told me that he unfortunately missed the inauguration ceremonies by arriving at the site too early. When he and a couple of companions reached the bridge, it was deserted, so they proceeded to bathe in a nearby pool of the river. The arrival of the dignitaries invited for the occasion surprised them in the water, and the imprudent location of their clothing, within sight of the bridge, made it necessary for them to prolong their bath until the exercises were over.

As the inevitable cup of champagne was passed, and an admirer of the technical ability of Dr. Villa proposed the toast, "*Que viva* ["long live"] *José Maria Villa*," that unimpressed and insuppressible individual, thinking perhaps of another ability, responded for himself, "*Que beba* ["long drink"] *José Maria Villa*."

The development in recent years of motor traffic in Antioquia has brought an unexpected responsibility to the Puente del Occidente. Automobile service between Antioquia and Sopetran has been available for several years, and the opening, in 1928, of the *Carretera al Mar* ("Highway to the Sea") between Medellin and Cañasgordas has brought a considerable freight traffic to the bridge. This route is projected to the Gulf of Uraba. It is noteworthy that Dr. Villa's original report foresaw such a highway but not, of course, motor transportation. Further work on the Carretera al Mar and improvement of old pack trails now permit motor transport from Cañasgordas and Frontino to Medellin, by way of the Puente del Occidente, in one day. Formerly this trip required three or four days. An alternative location for the highway has been surveyed but not built. It isolates Sopetran but reduces the journey by 14 km (8.7 miles) and avoids crossing the Puente del Occidente.

A traffic regulation recently adopted prohibits the passage over the bridge of vehicles heavier than $1^1/_2$ tons. The chief objection to the bridge for motor traffic, however, is the sharp turn at the north approach, a feature that was no inconvenience to pack trains. Unfortunately, topographic limitations do not permit any alteration of this approach.

In 1927 the average daily traffic on the bridge consisted of 89 pack animals loaded with merchandise, tobacco, coffee, beans, salt, and brown sugar; 11 head of cattle; 14 head of pigs or sheep; 79 persons on foot or mounted; 17 unloaded pack animals; and 9 motors.

Dr. José Maria Villa, designer and constructor of what was then the longest suspension bridge in South America, died at his home in Medellin, Colombia, on December 3, 1913.

For the compilation of this article, the author acknowledges the selection of data from the report prepared for the manager of the Carretera al Mar by Dr. Gustavo White. The detailed drawings were prepared by Horace L. Wilcox, Assoc. M. Am. Soc. C.E., who made an exhaustive survey of the structure while he was Office Engineer for R. W. Hebard and Company, Inc., on its Carretera al Mar contract.

Drawdown–Capacity Curves for Water Wells

Typical Curve Forms and Their Interpretation for the Selection of Pumping Machinery

By H. C. SCHWALEN

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ASSOCIATE AGRICULTURAL ENGINEER AND ASSOCIATE PROFESSOR, UNIVERSITY OF ARIZONA, TUCSON

SELECTION of economical machinery for the pumping plant of a water well is an interesting study dependent on the relation of the amount pumped to the drawdown in ground-water level. Only a few pumping tests are needed for the extrapolation of drawdown–capacity curves with reasonable accuracy, if the engineer has the aid of the well-driller's log, a general knowledge of the geologic structure of the locality, and a familiarity with the usual shape of such curves. In this article Mr. Schwalen points out the conditions which influence the shape of the drawdown–capacity curve and gives examples taken from typical Arizona wells.

SELECTION of an economical pumping plant for a deep drilled well in all cases requires some knowledge of the drawdown–capacity characteristics of the well in question. In most cases, however, data as to the capacity of a well are available for only one, or possibly two, test points. Often it is found impracticable to make a preliminary capacity test at as high a rate of discharge as is desired in the permanent pump installation. The test is made at only one rate of discharge, and in estimating the desired pump capacity the drawdown is assumed to be directly proportional to the discharge. Most engineers make an allowance for this deficiency in their data by adding to the estimated drawdown some arbitrary amount as a factor of safety.

A knowledge of geologic conditions and a careful analysis of the driller's log may be used to supplement insufficient data on the drawndown–capacity characteristics of a well. Experience has shown, however, that the correct interpretation of the ordinary driller's log is extremely difficult without an understanding of the terminology of the particular driller or an intimate knowledge of the region. Whenever possible, a close examination should be made of the drill cuttings or bailings from the well. Often a casual examination indicates an open, porous stratum of sand or gravel when a closer inspection would reveal the presence of cementing material, clay, or other fine substance which makes the strata relatively impervious and non-water-bearing. The occurrence of a perceptible amount of fine material in a sand or gravel stratum will greatly reduce its capacity for transmitting water and therefore the yield of the well which drains water from it.

Three cases have been selected to illustrate the relationship that exists between the drawdown–capacity curve, the type of well, and the formation in which it is drilled. The three wells considered are probably typical of many others. Their logs and their drawdown–capacity curves, which are the result of actual tests, are presented in Fig. 1.

In Fig. 1, the curve marked University of Arizona No. 2 is the result of a test on a well located on the campus of the university at Tucson, Ariz. This is a drilled well, 320 ft deep, cased with a 12½-in. screw casing, in which the static water level stood at 82 ft from the ground surface. By means of a four-way perforator, about 4,400 holes were punched in the casing between a depth of 90 ft and the bottom of the well, at a depth of 320 ft.

As shown by the log of this well, no distinct water-bearing strata were encountered, although the original log of the driller did classify the material between 82 ft and 90 ft as a coarse, loose sand with little clay. A further note, however, stated that water was required for drilling purposes until a depth of 95 ft was reached, which is clear evidence that the amount of water in this stratum was negligible. Examination of drill cuttings showed the presence of more or less clay and calcium carbonate as a cementing material throughout the entire depth of the hole. Calcium carbonate is the common cementing material in the valley fills of the Pleistocene period in the Southwest.

Almost a perfect straight-line relationship between drawdown and capacity throughout the entire range of the test is shown in the University of Arizona No. 2 curve. The results of the test, combined with a study of the well log, would indicate that this curve could be extrapolated as shown, by continuing the straight line, with very little danger of introducing any large error. It appears that the water-bearing strata are encountered throughout the entire depth of the well and that no individual stratum yields any large amount of water. In a well as

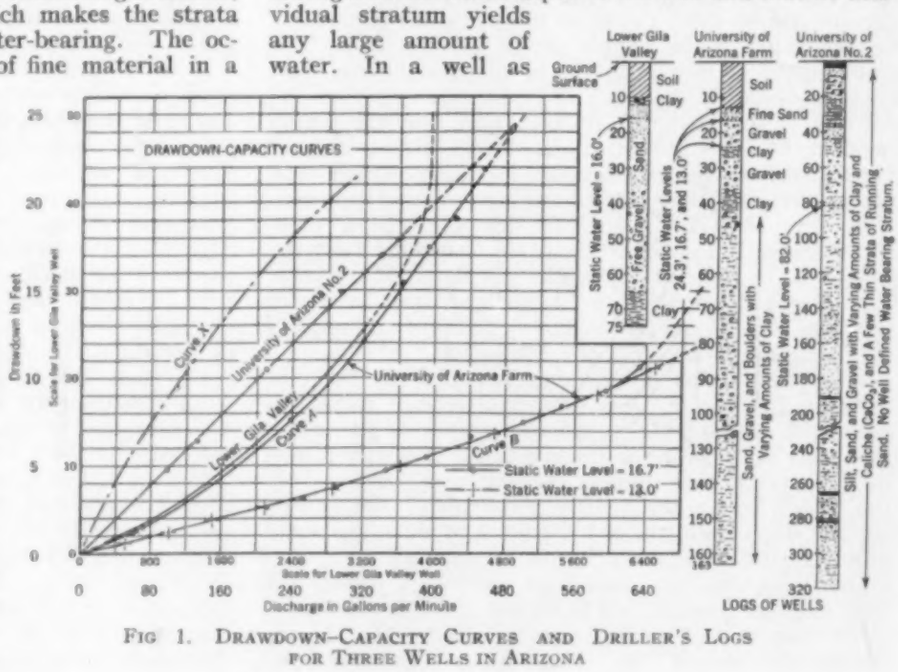

DRAWDOWN-CAPACITY CURVES
Drawdown in Feet
Scale for Lower Gila Valley Well
Discharge in Gallons per Minute
Curve X
University of Arizona No. 2
Lower Gila Valley
Curve A
University of Arizona Farm
Curve B
Static Water Level – 16.7'
Static Water Level – 13.0'
LOGS OF WELLS
Lower Gila Valley
University of Arizona Farm
University of Arizona No. 2
Ground Surface
Soil
Clay
Fine Sand
Gravel
Static Water Level – 16.0'
Static Water Levels 24.3', 16.7', and 13.0'
Sand, Gravel, and Boulders with Varying Amounts of Clay
Static Water Level – 82.0'
Silt, Sand, and Gravel with Varying Amounts of Clay and Caliche ($CaCO_3$), and A Few Thin Strata of Running Sand. No Well Defined Water Bearing Stratum.

FIG 1. DRAWDOWN–CAPACITY CURVES AND DRILLER'S LOGS FOR THREE WELLS IN ARIZONA

deep as this one, the drawdown represents only a small proportion of the depth of the well below the water table, and such a straight-line relationship is to be expected. In deep artesian wells this same type of curve is to be looked for, except in cases where the friction losses in the well casing are appreciable.

In the recent fill of the bottom land of the Lower Gila Valley, near Aztec, Ariz., is situated the Lower Gila Valley well, also included in Fig. 1. This well, which has a total depth of 75 ft and a static water level at 16 ft below the surface, is cased with 24-in. double stovepipe casing. No information is available as to perforations, but it is assumed that they were made with a knife perforator, since that is the one ordinarily used for this type of well. The log, as given in Fig. 1, shows a continuous, good water-bearing stratum from the water table to a depth of 65 ft, underlain by a stratum of clay through which the well does not penetrate. The concave character of the curve is to be expected, for with each foot of drawdown there is a corresponding increase in the amount of water-bearing stratum unwatered, and a resulting reduction in the total cross-sectional area of the water passages surrounding the well. An extension of this curve beyond the tested capacity of the well would undoubtedly take somewhat the form shown by the part of the curve indicated by dashes. As the drawdown is increased and the water level approaches the bottom of the water-bearing stratum, a maximum capacity is reached.

Another well for which the log is shown in Fig. 1 is situated on the University of Arizona farm on bottom land of the Rillito River, within a few hundred feet of the bank. The water level in the well is subject to wide fluctuations due in part to the comparatively small underground storage in the valley and in part to irregularity in the periods of flood flow in the river. Since the bed of the stream is composed of coarse sand, the rate of recharge of the underground waters is rapid, as shown by the almost immediate rise in well levels along the river following flood flows.

In Fig. 2 is given a graphic record of the fluctuations of the water level in the University of Arizona Farm well for the past 14 years. The well consists of an 8-ft concrete caisson to a depth of 30 ft and a 12-in. stovepipe casing to a depth of 163 ft, the bottom of the well. Perforations in both sections are believed to be sufficient to make the friction loss a negligible factor in the drawdown. Examination of the driller's log and inspection of samples at the time of construction indicated that the greater part of the water would have to be derived from the sand and gravel strata above the 36-ft depth.

Curves *A* and *B* in Fig. 1 are the result of three different tests. For curve *A* the static water level in the well was at 24.3 ft below the ground surface, and for curve *B*, at 16.7 and 13.0 ft below. Examination of the log of this well (Fig. 1), together with experience with other wells in the valley, led to the expectation that very little water would be drawn from the deep strata. It was expected that tests of the well at different water levels would result in entirely different drawdown–capacity characteristics.

Curve *A*, from tests made when the static water level was at 24.3 ft below the ground surface, shows the typical concave form for the smaller values of drawdown. This is because a considerable part of the principal water-bearing strata was uncovered. When the drawdown was increased beyond 11 ft it became directly proportional to the discharge; that is, a straight line relationship existed. This would indicate that the maximum capacity of the shallow strata had been secured and that the deep strata had the same characteristics as were found in the University of Arizona No. 2 well.

Curve *B* is the result of two different tests, with the static water levels at 13.0 ft and 16.7 ft, respectively. In each case the drawdown–capacity relationships

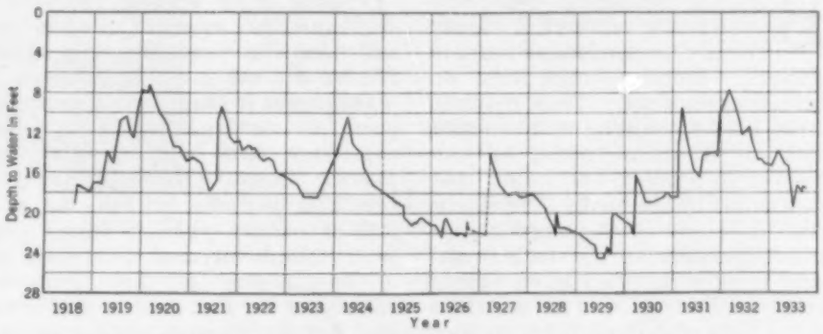


FIG. 2. GROUND-WATER LEVEL AT UNIVERSITY FARMS, TUCSON ARIZONA
High Water Table Quickly Follows Heavy Rainfall and Flood Flow in the River

are practically identical, as shown by the very slight deviation of the test points from the curve, with the one exception of the last point for a static water level of 16.7 ft. The curves of these two tests continue to coincide until a drawdown of approximately 10 ft is reached. At this point, when the static water level is at 16.7 ft, the total depth to the water in the well is almost 27 ft. The first water stratum is then completely uncovered. Except immediately adjacent to the caisson walls, it is probable that the clay stratum between 25 and 27 ft below the surface serves as a partial barrier to the downward movement of the water, and the water-bearing strata above a depth of 27 ft have under this condition been developed to their maximum capacity. It is logical to assume that, with increased drawdowns, the position of these curves as extended would finally become parallel to the straight-line part of curve *A*.

Curves *A* and *B* represent about the complete range in variation of the drawdown–capacity characteristics of the University of Arizona Farm well. In this case the selection of a pump to meet any fixed discharge requirements is difficult, even with adequate test data on the well. Thus, for a discharge of 500 gal per min, the total lift may vary from 25 to 50 ft, depending on the static water level in the well.

Curve *X*, in Fig. 1, is not the result of an actual test but is a type of drawdown–capacity curve occasionally found. Such results should always be viewed with suspicion, for they are contrary to the theory of groundwater flow as well as to the findings of experimental work. A possible explanation for such results may be that the well was not completely developed before testing and that its specific capacity continued to increase during the process of testing. Specific capacity is defined as the discharge per foot of drawdown. Even so, the results, although misleading, would not show the convex form of curve *X* unless during the tests the discharges progressively increased as improvement took place in the well.

In this discussion losses at entrance to the well and friction losses in the well casing have not been considered since these factors should be of relatively small importance in properly-constructed wells. When they are important they tend to increase the upward curvature.

Publicly Owned Transportation Facilities

Their Proper Administration Requires Tolls Commensurate with the Cost of Furnishing the Service

By J. Russell Wait

Director of the Port of Houston, Tex.

PRIVATELY owned industries must be managed so that they will return a profit to their owners. If they are not so managed either the management is changed or the company goes into bankruptcy. From a long experience with both privately and publicly owned facilities, Mr. Wait concludes that the citizens—the stockholders in any publicly owned enterprise—should demand this same sort of management of their properties. He points out that this rarely happens and that an improper understanding of the public interest to be served is likely to lead to faulty bookkeeping, which shifts such items as depreciation, maintenance, obsolescence, and other fixed charges to the general taxpayer to the financial advantage of the strong special interests which use the facilities offered. This paper was originally presented at a meeting of the Texas Section of the Society, in May 1933.

BEFORE becoming connected with public ventures, it was my fortune to spend many years in various executive capacities on private enterprises. These required strict cost accounting and exacting methods of management, all calculated to produce one result, that is, a profit to the owner. It is true that, in many of the larger industries thus managed, the stock ownership is so widely scattered among many individuals that to me there is but little difference between such an industry and a public property, the stock of which is exclusively held by many individuals, known as taxpayers.

Some constructive thoughts may be of interest on the problems of administering publicly owned properties along businesslike lines, free from undue interference and from improper service to selfish interests and, at the same time, without ever overlooking the basic requirement that the public interest involved must be properly served. It has taken me many years of close application to find just what the public interest involved may be, and with a view to developing this theme, in the briefest possible manner, I will sketch the growth of publicly owned transportation facilities in this country and some of the problems which have followed as a result of the large expenditures made.

Public ownership of transportation facilities is not a new thing. For the past hundred years there have been many interesting ventures, all made possible by the expenditure of "O.P.M." This term, which was furnished me by a very able and prominent banker in Charleston, S.C., will aid in visualizing clearly some phases of the administrative problem involved in managing a property constructed with "other people's money." Once one is in charge of such a property and can conceive a definite picture of the public interest, then it becomes much more easy to serve this interest and in turn protect the "O.P.M." invested.

Such transportation ventures may be divided into three general groups: first, canals and waterways; second, railroads; and third, rail-water terminal facilities.

CANALS AND WATERWAYS

Of these, the first group, canals and waterways, in their beginnings in this country followed the older European practice. In the early thirties the Illinois State Legislature issued $10,237,000 in bonds for transportation purposes, and it was proposed to build a network of such waterways, which would greatly enhance values and promote prosperity, even though it placed a burden of some $34.10 per capita on the hard-working pioneers of the state. This activity was followed by a sweeping out of office of all participants in the irregularities which accompanied the expenditure of these vast sums. It has always seemed easy to paint a glowing picture of the possibilities of development to follow the expenditure of public funds, but it has never yet proved easy, in these United States, to administer and manage properly the facilities built by these funds.

In the thirties and forties of the past century there was much confusion as to whether railroads or canals would ultimately prove to be the more advantageous for transportation. The State of Illinois was the first to build such a facility by statute, and in 1831 it made a survey of a route from Chicago to the Illinois River, to be constructed with state funds. It required many years to decide whether it should be a canal or a railroad, and it was not until 1837 that the money was appropriated.

Simultaneously with this activity, there was a desire on the part of that same state to become connected by rail with the Gulf. In 1849 Stephen Douglas introduced a bill which became a law in 1850 and granted 2,600,000 acres of land in the states of Illinois, Mississippi, and Alabama for the purpose of constructing a railroad from Chicago to Mobile. This was the first large venture of this type—including over 700 miles of new road—to be proposed and constructed.

PUBLICLY FINANCED RAILROADS

During this same period the City of Charleston, S.C., the terminus of the first railroad built in America to be operated by steam locomotives, constructed a railroad to Hamburg, directly across the Savannah River from Augusta. This project excited the imagination of the capitalists and engineers of that time. It was to have a slight grade, on which the cotton of the Mississippi Valley could flow to the then prosperous and growing port of Charleston, S.C. Throughout the forties and into the fifties a determined effort was made to build this great railroad, known as the "Memphis to Charleston Line." It would be of great interest for any one visiting the region of the Great Smoky Mountain Reservation to search out the tunnels and fills which were built up to the panic year of 1857 and which have never been finished. Some tunnels were excavated in the hardest of granite by hand labor.

Since the cost of the work far exceeded the funds made available by the originators of the scheme, they called on the City of Charleston, the State of South Carolina, the State of Tennessee, and the State of Georgia to help, and all of them contributed generously.

It began as a 3-ft gage railroad, but before its completion the plans were changed to conform to the standard gage which had in the meantime developed. Approximately $10,000,000 of public funds was invested in this project, and many sections of the railroad were completed. When the crash of 1857 destroyed the possibility of finishing the plan, these completed sections were gradually absorbed by other systems. The unfinished parts remain today as a monument to an enterprise which was financed almost exclusively by public funds obtained from the sources indicated. Since that date the old City of Charleston has had to pay tremendous sums as interest on these bonds. This has had a very serious effect on the ability of the city to make the progress which other cities not so burdened have made.

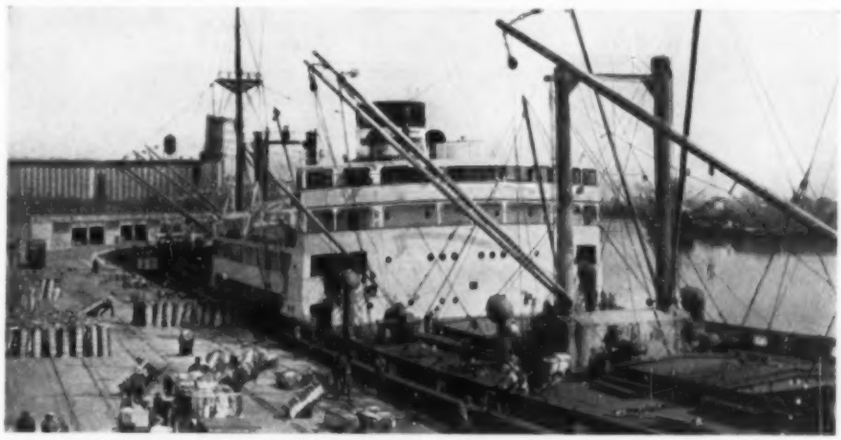
JAPANESE VESSEL LOADING COTTON AND CARBON BLACK
At Public Docks, Port of Houston, Tex.

During the period from 1830 to 1860 the great fear of the people was the fear of monopoly. They feared to allow private ownership of the cars, the motive power, and the track. For example, in Pennsylvania a "turnpike" equipped with rails was built with the idea that it would be owned and kept for all time by the state, and on it persons were to be allowed to operate their own vehicles at their own convenience. Of course this became impossible when the traffic grew heavy, and it was found necessary to create an ownership of the facility that could police and regulate traffic and not interfere with the public interest.

The third group, terminal facilities, is the newest transportation field entered by public ownership. Certain circumstances made public ownership advisable in San Francisco and New Orleans, because of conditions in the original Spanish land grants. These have had an important influence on the policy followed at these ports. It was not until the nineties of the past century that a proper port administrative body was created at New Orleans, and this did not become active until early in the present century. It started off in a small way. The original port group borrowed money on its own security to finance small ventures and gradually built up a stable policy and an organization which enabled it to borrow funds and to carry all its expenses out of earnings from the venture. This is probably the only example of a self-sustaining public facility in this country, but recently it has been affected by economic conditions and has required a subsidy from the gasoline tax of the state.

In the last thirty years there have been many of these public ventures, all initiated because of the belief of the many interested communities that they were being discriminated against and, perhaps, restricted in their growth by the failure of private capital to provide proper facilities for them. In general, public ownership has resulted from ambition on the part of communities, and has been followed by many astounding developments. Once the development has come, I have not yet seen the publicly owned facility which has been so administered that an adequate direct return has been made to its owners—the public.

When explanations are necessary, the administrators of the property fall back on the stock statement that the indirect return is adequate and a direct return is not necessary. They go so far as to say that since the facility is publicly owned it is like a park or a playground, open to the public. They miss the fundamental point that the park, the highway, and the recreation facility are open to all alike and used by all alike. A publicly owned transportation facility is especially adapted to some peculiar kind of transportation, and therefore is of great service and value to particular interests and individuals. These interests gradually become powerful enough to control the movement of traffic on these transportation facilities, so that they reap highly profitable harvests from the private enterprise which grows around and depends on these facilities. Fixed charges, depreciation, and other factors which make up overhead are left to be carried by the general public. When these facilities come into direct competition with similar, privately owned facilities, much destructive controversy and criticism result.



PUBLIC DOCKS AT HOUSTON TURNING BASIN, TEXAS
Grain Elevator in Background

In general, this is the situation on all publicly owned transportation facilities. Today there are almost no major railroads publicly operated, although there are some which are owned by the public but are leased to the large railroad systems. But I do not know of any instance where such a publicly owned railroad is adequately carrying its fixed charges. As for publicly owned waterways, their failure to earn a return is even more noticeable.

There is approximately $600,000,000 of public funds invested in the ports of Canada in transportation facilities, including grain elevators, railroads, wharves, and docks. In the United States approximately $200,000,000 has been invested in waterway improvements. This includes canals, harbor entrances, and harbor protective works. In addition, probably $500,000,000 has been invested in publicly owned rail-water terminal

facilities in the ports. The size and scope of the industry is indicated by this stupendous total.

GETTING A RETURN FROM THE PUBLIC'S INVESTMENT

What is the true situation confronting the managements of these properties, and what are the influences that are brought to bear on these managements which prevent operation on or near a remunerative basis? In general, these public investments are the result of a desire by community leaders to improve the community. Naturally, they think first of borrowing from the public because it is easy to show the public the direct results which they claim will result from such investment. Actually, in my long contact with this problem, I do not recall any such venture that has worked out on a remunerative basis. On the contrary, as soon as the bond funds are spent, the job of management becomes impossible to the average industrial executive.

The first thing that strikes the student of this problem is the lack of interest on the part of the average citizen of the community in a remunerative operation of the property. On the other hand, the special interests which use these publicly financed transportation facilities are so capable and so well informed that they can bring to bear on the management influences which absolutely prohibit remunerative operation of the facility. Some of the factors involved are very complicated and require a knowledge of private enterprise that will place the public management on an equal footing with the interests endeavoring to secure the use of public properties on a less-than-cost basis.

LOADING DIRECT TO CARS FROM SHIP
Port of Houston, Tex.; Turning Basin in Background

One of the standard arguments is that if the toll charge on these publicly owned transportation facilities is reduced, there will be an increased volume of business which will be good for the community. If the management explains to those desiring less-than-cost service that the wear and tear, and therefore the cost to the community, is increased proportionately with the volume, they immediately remind the management that this is all right because the indirect return to shippers, users, labor, supply houses, and other interested parties will more than make it up. It would be easy to approach the management of a publicly owned transportation facility with the argument that a reduction in the rate would bring more imports and thus make a better showing for the port. On the other hand, it must be evident that this would impose a form of subsidy on the community, which would be directly used in promoting competition with privately owned industries. Therefore it seems entirely practical and proper that the toll charge for the use of public facilities should equal the actual cost of furnishing the service.

While those who may be interested in steel and cement are approaching public managers, there are others from the lumber, cotton, ore, coal, coke, fertilizer, and other industries which move and handle large tonnage, all bringing unusual pressure to bear. Then comes a test of strength between the public management and the influences which the private enterprises can bring to bear. If the management contains individuals formerly associated with competitive enterprises, the charge is promptly made that these enterprises are exerting undue pressure on the management for their own ends. If these charges can be substantiated, it does not take long to make a change in personnel that will be more satisfactory to those who wish to use the public facilities for their own gain.

VESSELS PASSING IN HOUSTON SHIP CHANNEL
Port of Houston, Tex.

Four short years ago any public official occupying an executive position on a public transportation facility who dared to argue on the propriety of furnishing some service at less than cost, and who tried to protect the public interest against such influences, would have been attacked and instantly destroyed as a non-progressive and short-sighted individual, obstructing the free flow of commerce. Because of the unusual prosperity that then existed, it was comparatively easy to get rid of any official who might have an ambition to secure for the public a slight remuneration for the valuable services which its transportation facilities furnished to interests both large and small.

BUSINESS-LIKE MANAGEMENT SHOULD BE EXPECTED BY THE PUBLIC

Why should such a condition be allowed to exist and why should it be fostered by taxpayers as well educated as those of the United States? The actual owners should expect a businesslike management; individuals among these owners who derive great benefits from the use of the facilities should be made to pay for them. If these individuals are fair minded they should be willing to do so. It has been my experience that the average user of public facilities looks on them as a convenience by means of which he can carry on highly profitable activities without any thought of paying for the actual services rendered. There does not seem

to be any room for a businesslike management or for the building up of an organization which can resist these influences and collect the money that is due the public.

Some will find the reason for this condition in politics, meaning interference from officeholders and the granting of special privileges to large interests. This is only one phase of the problem. Political considerations have less effect on the securing of a businesslike administration of a publicly owned transportation facility than the pressure which large and powerful interests can bring to bear on the management directly. Once a large interest makes charges of inefficiency against the public officials—high cost, politics, or any of a long list of charges that can be easily made—the management is then on the defensive as long as it lasts.

LOADING GRAIN ON SHIPS
Public Elevator at Port of Houston, Tex.

Recently many indications have appeared of the need of facing this problem of public ownership in a more businesslike way than has ever been done in the past. We have all witnessed the breakdown of the administration of the oil fields, Shipping Board vessels, railroads, and all other activities where public ownership was involved. A search to the bottom of these difficulties will reveal that in this country there is a general resentment against public ownership on the ground that it interferes with private initiative. On the other hand, it will also be found that the country has now grown to have such a complicated, intricate structure as to make it impossible to separate the many interests involved. In all such instances the paramount interest is undoubtedly the public interest. There must be a change in our attitude toward these publicly owned properties. The only change that would be necessary in order to make their successful operation possible would be for the public to insist on a management as energetic, as honest, and as well informed as similar managements of privately owned corporations.

PUBLIC OWNERSHIP HERE TO STAY

Probably this idea is ahead of the time; nevertheless it is timely. There can be no abandonment of public ownership of many transportation facilities and activities which are so interwoven with the public welfare as to make it impossible to turn them over to some private organization to administer on a selfish basis. There is no field that offers more opportunity for real public service than that of administering these colossal facilities which affect so prominently and so completely the public welfare.

Some of the problems that prevent the realization of these ideal conditions are very difficult to solve. It is easy to defer making charges for depreciation; it is easy to delay proper maintenance; it is easy to overlook obsolescence. If all this is done, there results a false level of cost, and then a low level of income. After a few years, when the results of this course are realized, out goes the old management and in comes a new one. Then the lesson must be learned all over again.

It seems impossible in this country to pay adequate remuneration to the executive management of these large properties because, the minute this is done, many influences are brought to bear on the officials concerned that make the work very unattractive. The amount of the remuneration is the only factor that many people see. The service to the public interest may be completely forgotten and, in fact, may not be desired by those who are proposing a new form of management. They will of course advise the community and the owners that this change in policy would be good for all concerned.

If the long list of publicly owned transportation facilities that have appeared in the past one hundred years is examined, no case will be found in which there has been a good, constructive, long-time policy, designed to serve the public interest and administered by an organization trained to carry out the policy established. In this long list there are many instances in which the policy has changed from severe political manipulation to lax business administration, all the time costing the taxpayers money. In many instances, the taxpayers have finally stepped out of the active management and have turned the facility over to some private individual energetic and influential enough to manage it to his own gain while they pay the fixed charges. If the list of publicly owned properties now in this category is examined, an astonishing number will be found that have caused the public to throw up its hands, unable to find the correct policy under which to administer its own property.

ATTRACTING COMPETENT MANAGERS

In a country such as this, containing thousands of well-educated and well-trained men, it is surprising how few are willing to serve the public interest. Probably the first reason is that the remuneration is not attractive, and the second, that the never-ending demand by well-informed and powerful interests for special consideration makes the work highly controversial—a continual struggle to understand these influences and to make sure that the public interest is being properly served and that some private interest is not gaining an unfair advantage.

Community interest is strong. If community "A" hears that community "B" is furnishing a service at half the cost in "A," and community "C" learns that community "B" is being served by a transportation agency at a lower rate, there is instantly a demand that this competition be met. No thought whatever is given to the ultimate cost of such a policy to the public. If the management fails to heed this demand, it will spend most of the time defending its job to the ultimate detriment of the whole publicly owned project.

This matter of influences and interests to be served is an old one in this country. There is no possible end to serve that compares with the public interest once it is possible to determine where it lies. This thought was stated so admirably by Gen. Sam Houston as to prompt me to quote him verbatim. He said, "Sentiment tells well in affairs of love, but the affairs of nations have no soul and recognize no mentor but the interest to be served."

Are the Professions Crowded?

An Investigation of Numbers, Ages, and Employment with Special Reference to Engineering

By DAVID L. FISKE

SECRETARY, THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS, NEW YORK, N.Y.

DURING times of general unemployment the query which provoked this article has frequently been made. In attempting to find an answer Mr. Fiske has consulted the census records of professional and technical engineers since 1890, the American Experience Table of Mortality, and the record of graduations from schools of technology. In the employment history of these men he has sought an indication of the fortunes of their fellows in the future. Although the younger men of the profession are generally better educated than the older ones, up to 1930—that is, prior to the depression—competition for employment had become increasingly great. There are very clear signs that the engineering profession will be overcrowded probably to a greater extent than any one of the other professions. Employment conditions faced by the young engineer in 1930 were greatly different from those confronting graduates of 30 years before. The surviving engineering graduates in the decade 1920–1930 exceeded the number of engineers employed in that period, which fact indicates that many had turned to other lines of work. In the future, opportunities in the engineering profession for non-graduates appear to be slim indeed.

OUR professional population, statistically regarded, has had little attention in the past. If the conclusions resulting from this study of the numbers, ages, and employment of men in several professions from 1890 to 1930 seem unexpected, it is because of this fact. Such an analysis is more fundamental, and contributes more to an understanding of the situation, than that of such matters as the education, income, and character traits of engineers, which are more often discussed.

The statistical data here used come from common sources, such as the decennial United States censuses. They were arranged in ten-year age groups, which have been further combined according to the date of birth of several continuing groups. Thus the employment history of a definite group of men may be compared with that of another, and some notion may be obtained as to how the fortunes of the past may foretell those of the future. By including in the analysis the annual increment of graduating students, the manner in which the growth of the whole number is affected can be seen. As regards the engineering profession this factor is dominant in the past two decades, when there was a very rapid increase in the numbers of graduates.

Survivors of that period and of the continuing annual increments of new men, foretell a further increase in numbers. This will be the case regardless of reduction in the college enrolment, unless that reduction is carried to a degree which seems unlikely now. No comparison is made here between the probable number of men in the engineering profession in the future and the possible future demand for technical engineering services. Although the question of such demand leads to tenuous analysis, it is by no means futile or unimportant. My own opinion is that the demand for such services will not greatly increase in the next decade or two above what it was from 1920 to 1930.

TABLE I. TOTAL NUMBER OF MALE PERSONS ENGAGED AS TECHNICAL ENGINEERS

According to the Eleventh and Fifteenth Censuses

YEAR	NUMBER STUDENTS	NUMBER ENGINEERS BY AGE GROUPS						TOTAL
		20–24	25–34	35–44	45–54	55–64	65–69	
1890[a]	1,195	9,848[f]	14,179	9,025	5,429	2,978	1,449	44,103
1900[b]	11,415	7,111[f]	14,550	9,945	6,360	3,321	194[l]	52,896
1910[c]	30,337	14,747[g]	29,606[h]	21,193[h]	12,774[i]	4,359[m]	345[m]	113,361
1920[d]	51,908	14,829	49,255[j]	39,791[j]	20,099[k]	8,259[k]	3,662[l]	187,803
1930[e]	58,853	25,273	7,216	62,380	39,265	16,136	3,361	282,484

[a] Occupations at the 11th Census; U. S. 52d Congress, first session, House Misc. Doc. No. 340. Part 27, Table 8, p. 88.

[b] U. S. Census Office; *Special Report on Occupations at the 12th Census*, 1900, Table 4, p. 16.

[c] *U. S. Census Reports, 13th Census*, 1910, Vol. 4, Table 6, p. 403, and *U. S. Census Reports, 14th Census*, 1920, Vol. 4, Table 4, p. 42.

[d] *U. S. Census Reports, 14th Census*, 1930, Vol. 4, Table 6, p. 392.

[e] U. S. Census Office; Occupation Statistics, *United States Summary, 15th Census*, 1930, p. 62.

[f] Ages 16–24.

[g] Total all ages 88,744 by *Census Report of 1920*, Vol. 4, p. 42. Distribution here based on that shown in *Census Report, 1910*, Vol. 4, p. 430; 16–20, 3,862; 21–44, 44,249; 45 up, 11,799; thus three chief groups for 1910 are 5,720, 65,546, 17,478. Of these, the group 21–44 (65,546) was subdivided to give the number 21–24 in proportion to distribution of ages of similar (20–24) groups in 1900.

[h] Remainder of operation of Note (g) (50,799)
[i] Remainder of operation of Note (m) (17,133) } subdivided into four groups, shown in such a way that they fall on straight line of same slope as that obtained by plotting half the original values against the corresponding ages.

[j] Total 25–44 (89,046) divided into two groups in proportion to distribution of ages of similar groups in 1930.

[k] Total 45–64 (28,358) divided as in Note (*i*).

[l] Ages 64 up.

[m] Total over 45 subdivided as in Note (*g*).

SOURCES AND METHODS OF ANALYSIS

All the statistics used are limited to males and to the period 1890–1930, thus being "pre-depression." Such deductions as are drawn disregard the employment influences at work in 1931, 1932, and 1933.

The statistics from the censuses represent "employment," as applied to engineers and others. As applied to engineers they also represent what is here called "enrolment" (assuming all engineers were employed) and what is here called "demand" (assuming no restrictions as to admissions). For other groups employment does not necessarily amount to either enrolment or demand.

The principal data were taken from the occupation statistics of the past five Federal censuses under the head of "professional service—technical engineers." In the case of the eleventh, twelfth, and fifteenth censuses the age groups are arranged to give directly the numbers shown in Table I. In the thirteenth and fourteenth, different age groupings are used. The method whereby the total is distributed to give the data in Table I is stated in the footnotes of that table. Some assumptions are involved, but examination will show that their choice has little effect on the results. In the 1910 census all figures are doubtful, since the total as originally classified did not include all branches of engineering, nor did it summarize the entries in one place. The data were rearranged, however, on the usual basis and published in totals in the succeeding census report.

Earlier censuses include only civil, mechanical, electrical, and mining engineers and surveyors, but in the recent ones engineers in other branches are in-

corporated with the mining and mechanical groups. The term "technical engineer," as used in these reports, is more definitive than the term "engineer," even as used in the engineering profession. The census elsewhere classifies inventors, designers, draftsmen, chemists, physicists, architects, stationary engineers, and

TABLE II. STUDENT ENROLMENT IN AND GRADUATION FROM SCHOOLS OF TECHNOLOGY, 1890–1930

YEAR	NUMBER OF STUDENTS	NUMBER OF SENIORS[a]
1890	1,195[b,c]	189
1900	11,415[b,c]	1,804
1910	30,337[c]	4,793
1920	51,908[c]	8,202
1926	59,315[c]	9,372
1928	66,637[c]	10,529
1930	58,853[d]	9,283[d]
	(70,000)[e]	(11,060)
1931	73,386[f]	11,595[g]

[a] Numbers are 15.8 per cent of the total number of students, equal to the number of senior students per 100 total group (9,283 in 58,853) in 119 schools in 1930, Note (*d*); this ratio confirmed by records of 38 schools for 30 years in *Report of Investigation*, S.P.E.E., 1928–1929, p. 221.

[b] *Biennial Survey of Education*, U. S. Bureau of Education, *Bulletin No. 90*, 1919, p. 681.

[c] *Statistical Abstract of the United States*, 1932, p. 104, U. S. Department of Commerce.

[d] *Report of 1930 Survey*, S.P.E.E., p. 9.

[e] Estimated by authors of *Report of 1930 Survey*, S.P.E.E.

[f] *Journal of Engineering Education*, November 1932, p. 166.

[g] Bulletins of the *Biennial Survey of Education*, U. S. Bureau of Education, show total graduations for certain schools as: 1930, 7,607; 1926, 7,377; 1924, 7,461; 1920, 4,538; by Note (*d*): 1931, 8,303; 1926, 7,896; 1922, 7,154.

others more or less likely to be included in the membership of engineering societies. The census totals are probably low because of the omission of men with engineering training who were more closely identified with other activities, yet properly belonged in the engineering group.

As for students, there is no summarized record of their number or of the number of undergraduate degrees conferred in the period 1890–1930. The U. S. Bureau of Education recorded the number of students in schools of technology from 1889 to 1904 in its "Biennial Survey of Education" on page 681 of *Bulletin No. 90* (1919). The *Report of Investigation* by the Society for the Promotion of Engineering Education (S.P.E.E.), 1928–1929, page 221, shows admissions and graduations for 38 schools from 1899 to 1924. Each of these agencies recorded data for subsequent dates. However, in order to use a single set of figures from one source, Table II, second column, shows the report of the Bureau of Education to the 1932 *Statistical Abstract of the United States*, found on page 104, except as indicated in footnotes to that table.

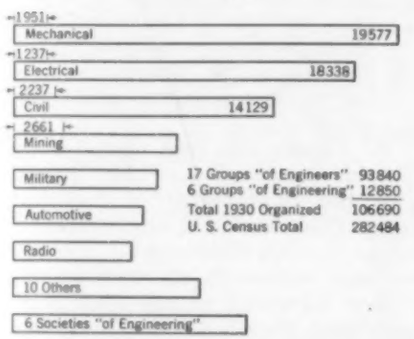


FIG. 1. NUMBER AND DIVISIONS OF THE ENGINEERING PROFESSION IN 1930

Smaller Numbers Show Enrolment in 1900; Taken from the 1930 Report on *Scientific and Technical Societies in the United States and Canada*, by the National Research Council

The main or continuing groups studied were those composed of men born in successive ten-year periods, as shown in Table III. In analyzing these groups, the number surviving from the number living ten years before was computed for each date, and the same kind of computation was used to determine the numbers surviving in 1940 and 1950, as shown in succeeding charts. The method used was an approximation. From the American Experience Table of Mortality the number living at age 35 was divided by the number living at age 25. A similar ratio was taken of those living at 44 as compared with those living at 34. The mean of these two ratios was then used as the ratio representing the part of those in the 25–34 age group living to make up the 35–44 age group. Similar procedure was followed for the next two ten-year periods.

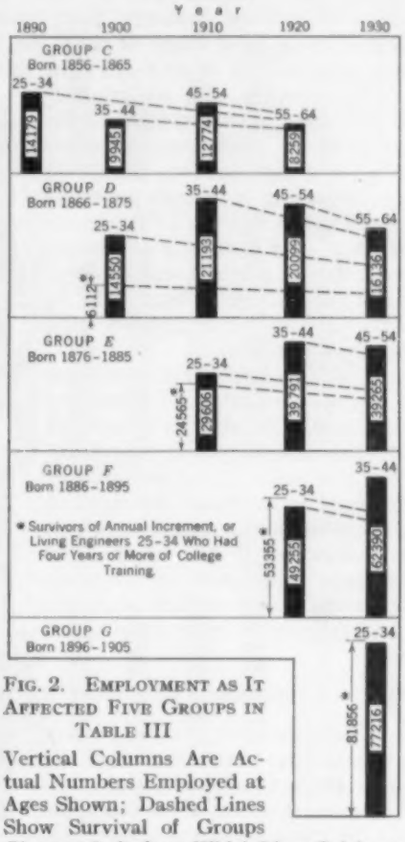


FIG. 2. EMPLOYMENT AS IT AFFECTED FIVE GROUPS IN TABLE III

Vertical Columns Are Actual Numbers Employed at Ages Shown; Dashed Lines Show Survival of Groups Given at Left, from Which Lines Originate

To determine the number of graduates that live to take a place in a 25–34 age group, the data of Table II were first extended by interpolation to include the number of graduates added each year. Each number in Col. 3 is 15.8 per cent of the enrolment shown in Col. 2, except as stated. The 15.8 per cent represents the proportion of seniors in the 1930 total for 119 schools (estimated gross, 70,000) as given in the *Report of the 1930 Survey*, S.P.E.E., page 9. In this report it is shown that freshmen constituted 37.3 per cent of the student body. If the seniors are taken to represent those graduated and the freshmen those admitted, the ratio of annual graduations to annual admissions will be 0.424. This appears to be a reasonable percentage. Comparison with the admissions and eliminations in 38 leading schools for the 30 years ending in 1924, shown on page 221 of the 1928–1929 investigation of the same society bears out this assumption. For the whole period, 40.8 per cent of those admitted were graduated.

TABLE III. GROUPING OF ENGINEERS BY TEN-YEAR PERIODS

GROUP	YEAR OF BIRTH	GROUP	YEAR OF BIRTH
A	1836–1845	E	1876–1885
B	1846–1855	F	1886–1895
C	1856–1865	G	1896–1905
D	1866–1875	H	1906–1915

The most recent data, shown in the Biennial Surveys of Education of the U. S. Bureau of Education, indicate that the ratio of annual graduations to total college enrolment is about 13 per cent. Thus when the "annual increment" of college men is referred to here, that is for the college classes 1918–1927, used in forecasting

future population, the reference is to the number who survived four years of education, so that the number getting degrees is smaller than the data here given would indicate by that amount. This results in an understatement of the annual increment as actually known, for if it is assumed that all those who have a year or more of college training later follow an engineering career, as a good share of them do, a ratio of about 23 per cent instead of 15.8 per cent should be used.

The average age at graduation is assumed to be 22, and the survival of each yearly increment of graduates into the 25–34 age group in a census year has been computed. In 1930, for example, 81,856 living engineers with four or more years of college work, of college classes 1918 to 1927, are to be compared with Group G (Fig. 2).

With this explanation and the citation of sources of data any one should be able to reproduce all the computations involved. The statistical data and figures deduced from them represent a statement of the situation which is consistent, if not exact. The absolute magnitude of the numbers used in such a study is always to be taken with a "grain of salt."

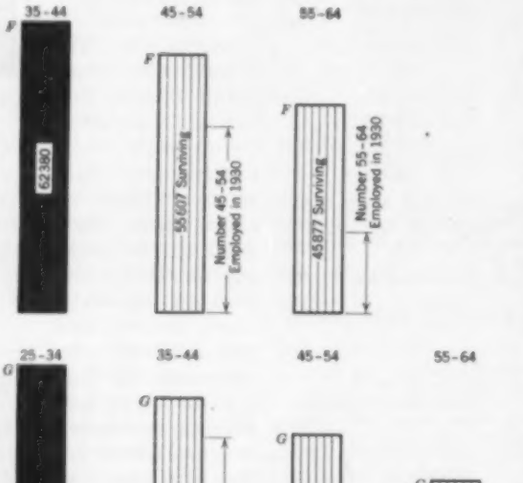


FIG. 3. OUTLOOK IN 1930 FOR ENGINEERS AGED 25–34 AND 35–44

More Men of Each Age Group Will Be Available Than Were Employed at the Same Age in 1930

YOUNG ENGINEERS PREDOMINATE

When a group is growing largely by an annual increment of young men, there must be a predominance of men between the ages, say, of 25 and 44 over those from 45 to 64. With enrolment in the profession increasing sixfold or more in the past 40 years, this condition is striking. It is enough in itself to explain peculiarities of the group which might otherwise be ascribed to some quite different reason. For example, to explain the wide variation in income between older and younger men, the more severe competition due to increased numbers which affects the younger men needs to be observed. Again, there is the wide gap between the higher-paid services of management and the lower rewards of pure technic. Here we find a smaller group of older men, on whom administrative duties are always more likely to fall, opposing a group of younger, technically better-trained men, whose much larger numbers would tend to lower the price of technical service.

Another generality of such an analysis which must be mentioned at the outset is that during rapid growth no danger signals are likely to be noticed. The growth of a group like this, whether geometric or arithmetic, cannot go on indefinitely without relation to general economic indices, such as general population, production, and wealth. Eventually it must be stabilized on some level. But when the growth comes from the continuing entrance of young men, as in this case, the total is very likely to exceed that stabilized level—to exceed the demand for a time—and then decrease, with painful consequences meanwhile. That is, each increment of young men may be trained and employed for a considerable period, say in the 25–34 age group, especially if times are good, yet these men may find themselves too numerous to secure the rewards which their predecessors enjoyed after their period of apprenticeship.

Up the scale the number of jobs is not merely a function of the number of aspirants. Uncertainty faces those in the younger groups moving into older groups previously smaller in size. There is an unseen competition at work which, to the individual, is more important than the other—if he judges his success in life more by the accomplishments of his father and his older brothers than by those of his classmates. This form of competition is very likely at some time to prove the more severe—although it is not known just when—so long as there are 2.5 to 3.1 times as many engineers between the ages of 25 and 44 as there are between 45 and 64; whereas the normal ratio among professional men, engineers included, is 1.8 or, for the whole male population, 1.6.

It is ironical that just the converse of all this is commonly assumed to be the case. Because employment has risen, we are told, things are getting better for all. "Because those older than I have done well," the engineer says to himself, "therefore I, with my improved technical training, will get my recompense in due time." He may get it, but his reason is wholly wrong. In engineering, unless there is a great increase in the demand for technical services coupled with a decrease in the educational rate, the whole supposition will prove wrong.

During the past thirty years the dominant fact has been a very rapid increase in the employment of technical engineers of all ages (Fig. 1), unrelated to most economic indices or to the number in other professions. Though the younger men were more numerous, the demand was growing so that as they advanced in age they were provided for—and more than they. An ideal condition of affairs was enjoyed by engineers born in the period 1866 to 1875, or by Group D in Fig. 2. In 1900 when this group was between 25 and 34 years old, living graduates made up less than half of it, and they constituted a still smaller part of it at later dates. These men were provided with competitive advantages often acknowledged by the observation that "college training pays." The influx of others was great but at each period shown on the chart except the last, those living ten years from the previous date were unable to supply the demand. Favorable economic circumstances for Groups D and E in 1930 were to be expected. Although the groups then constituted less than 25 per cent of the whole professional body, their unusual success lent weight to the claim that engineering incomes stand very high in the professional field (*Mechanical Engineering*, September 1931, page 651, subheading).

Whatever the accuracy of this idea, it is sure to prove disappointing if used as a criterion for predicting the future of the group as a whole, and especially of the

younger groups as of 1930. Considering Group F in 1920, the number of living college-trained engineers

TABLE IV. TOTAL NUMBER OF MALE PERSONS OF AGES 25–64 ENGAGED IN VARIOUS PROFESSIONAL SERVICES
Eleventh to Fifteenth Censuses

PROFESSION AND YEAR	NUMBER BY AGE GROUPS				TOTAL[a]	GRADUATIONS IN 1928[b]
	25–34	35–44	45–54	55–64		
Law:						
1890	25,687	23,691	17,237	10,558	77,173	
1900	33,087	28,704	21,502	14,098	97,391	
1910	32,777	26,273	19,761	13,252	92,063	
1920	33,682	29,410	25,940	18,188	107,220	
1930	43,479	37,964	32,474	22,770	136,687	8,209
Medicine:						
1890	26,814	25,649	19,716	13,441	85,620	
1900	37,252	32,928	23,206	14,665	108,051	
1910	43,532	35,021	26,509	17,998	123,060	
1920	31,999	35,358	32,479	24,635	124,471	
1930	30,296	33,476	37,636	28,545	129,953	4,155
Dentistry:						
1890	5,505	3,938	2,738	1,441	13,622	
1900	11,362	6,305	3,632	1,994	23,293	
1910	13,699	9,730	5,762	1,792	30,983	
1920	17,942	15,509	9,109	5,037	47,605	
1930	22,266	19,254	14,707	8,131	64,358	2,688
Architecture:						
1890	2,328	1,821	1,039	611	5,799	
1900	9,778	5,508	3,301	1,616	20,203	
1910	3,895	3,145	2,385	1,633	11,058	
1920	4,852	5,865	3,305	2,058	16,080	
1930	5,432	6,565	4,168	2,595	18,760	313[c]

[a] Same methods and modifications used for 1910 and 1920 distribution as explained in the footnotes of Table I.
[b] Bulletins of the *Biennial Survey of Education*, U. S. Bureau of Education: 1930, No. 16, pp. 709, 713; No. 25, 1928; No. 23, 1926; No. 29, 1923; No. 20, 1931, Vols. 1 and 2.
[c] Architectural engineers (172) excluded.

exceeded the number of positions available, as was the case for Group G in 1930. As these groups move into future decades they attain numbers at successive ages more than those of such ages previously employed, as shown in Fig. 3. This of course has been the case in the past for some other groups, even more acutely so in certain cases, as can be seen by reference to Fig. 2.

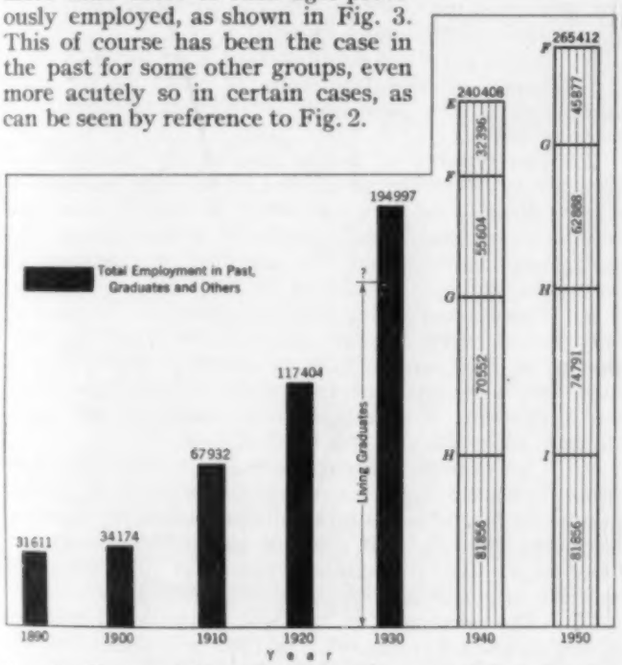


FIG. 4. FUTURE MINIMUM ENROLMENT OF ENGINEERS AGED 25 TO 64 COMPARED WITH PAST EMPLOYMENT
Considering Surviving Engineers and Student Increments, as Explained in Text. If All College Trained Non-Graduates in Groups H and I Are Added to the Estimated Enrolment for 1950, the Total Becomes 363,500

And in general, in most of the professional schools the number trained has been excessive, the assumption being that an increase in demand would occur. Thus of course it all comes back to the question of future demand. It is to be noticed here that only those now in practice as engineers and future increments of graduates are being considered. This is a very significant point not brought out in the diagrams, for to assume in Fig. 3 or Fig. 4 any entrance of non-graduates proportionate to the opportunities open to them a few years previously, is to arrive at such large totals as to make the effort meaningless. In asking if there will be sufficient openings in the future, it is enough to inquire what the future minimum number of engineers will be. The prospects are indicated in Fig. 4.

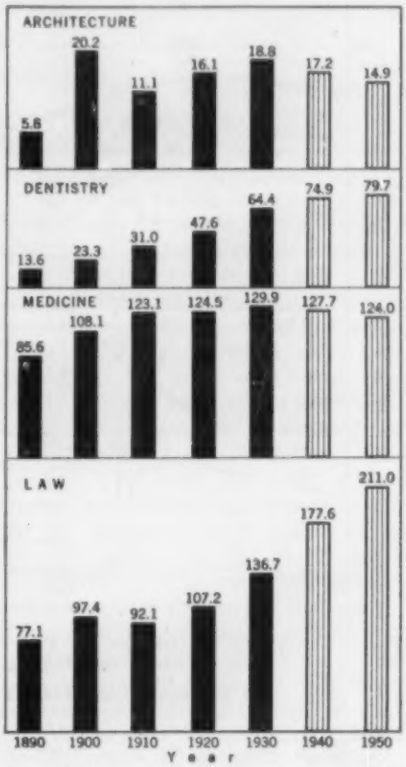


FIG. 5. PAST EMPLOYMENT AND FUTURE ENROLMENT FOR FOUR OTHER PROFESSIONS
Numbers Are Expressed in Units of One Thousand

It is to be noted that if the future influx of non-college-trained men is unlikely, substantially "closed" conditions prevail in our hitherto "open" profession. One survey, reported in *Mechanical Engineering* for November 1931, in Fig. 16 on page 821, shows the high extent to which degrees are held by the younger men. For the profession of the future the only thing that can be said with certainty is that college training pays in the sense that one cannot play the game at all without it.

TABLE V. RELATIVE GROWTH OF FIVE PROFESSIONS FOR THE AGES 25–64
Past Employment and Future Minimum Enrolment Related to 1920 as 100

PROFESSION	YEAR						
	1890	1900	1910	1920	1930	1940	1950
Architecture	36.1	125.5	68.7	100	116.7	105.9	92.5
Dentistry	28.6	48.9	65.1	100	135.2	157.4	169.5
Medicine	68.8	87.3	98.9	100	104.4	102.7	99.9
Law	71.9	90.8	85.9	100	127.5	167.4	198.1
Engineering	26.9	29.1	57.9	100	166.1	204.8	226.1

In Fig. 4 is shown the record of employment of men of ages 25–64 and the number of engineers in practice in 1930 that may be expected to survive until 1940 and 1950, plus survivors of the annual increments continuing at a supposed rate of education such as the classes 1918–1927 added to the 25–34 group in 1930. With four other professions, the census records of which are given in Table IV, the same procedure gives the data in Fig. 5. In this figure the 1928 rate of graduation was

assumed to continue. In Fig. 6 are shown the changes in several professions as compared with the growth in population of the country as a whole. Relative past and probable future increments to these same groups are given in Table V.

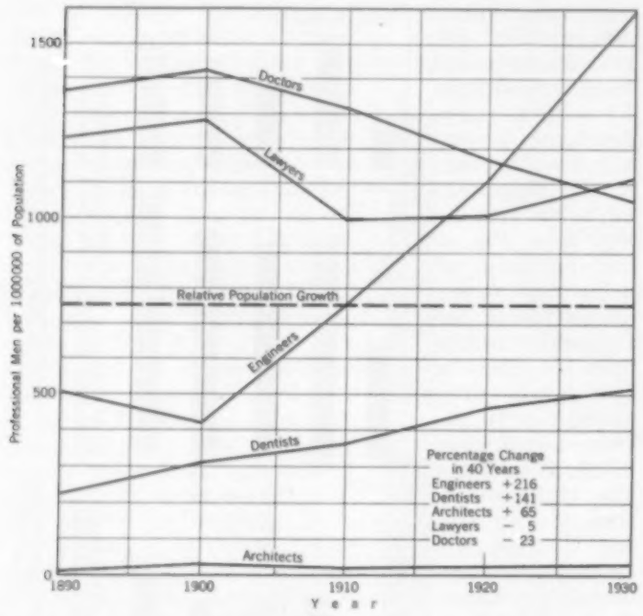


FIG. 6. CHANGES IN NUMBER OF PROFESSIONAL MEN OF AGES 25 TO 64 IN THE UNITED STATES
In Relation to the Total Population

College enrolments now appear to be above those prevailing from 1918 to 1927. Six more classes have graduated into Group H. It is rather striking to note from Fig. 4 that if this source of supply were cut off for seven years the number of engineers would continue to be above that in 1930.

I do not mean to give weight to the belief that, because employment of technical engineers increased enormously up to 1930, the men in question found their lot very satisfactory; or that a smaller number might not have done the work equally well, or better, with more temporal and enduring rewards for themselves. Indeed the implication of these data would support the common belief among engineers that their bargaining power is unusually low. It is a temptation to find in these figures support for the theory that engineering education responds to boom times like the manufacture of any standard line of goods. Overcapacity to produce leaves the usual troubles in its wake; and the product is consumed not so much at the time as from 20 to 40 years later.

Moreover, the claim that the period of technical apprenticeship has its reward in a migration into higher-paid managerial positions can find no support in these data. In the past the migration of older men has been into technical engineering rather than out of it (Groups D and E, Fig. 2). For the future it must be assumed that this migration will be compelled to stop; if it is reversed it will be merely for lack of jobs of the kind engineers are trained to fill. It is frequently maintained that the graduation of technical men into business managership is the general rule, as if to imply that this is the solution of the employment problem of engineers. Such is the implication, for example, of the data as presented in the *Report of Investigation*, S.P.E.E., 1928–1929, pages 232, 260, and in *Mechanical Engineering* for September 1931, page 656, and for December 1931, page 879. Quite a different implication will, however, be discovered in these same data if they are analyzed on the basis of actual numbers and continuing groups in the manner used in the present article.

The facts at hand show mainly that in the next two decades the number of men in the profession will probably increase a third over that employed in 1930, if newcomers are limited to those with four years of college training. Professional and educational programs which disregard this situation must assume that the demand for technical engineering services will increase proportionately.

CONCLUSIONS LISTED

On the basis of this study, the following conclusions seem justified:

1. The number of engineers, ranging from 31,600 in 1890 to a projected total of 265,400 (ages 25 to 64) in 1950 (Fig. 4), is the key to their social-economic status, and a factor of more importance than their training, abilities, incomes, organization, or other factors commonly given more weight.
2. Without regard to the employment influences of the current depression, statistics from 1890 to 1930 reveal signs of future overcrowding.
3. Engineers aged 25 and 44 have outnumbered those aged 45–64 by between 2.5 and 3.1 to 1 since 1910, whereas the corresponding ratio in these age groups for the entire male population of the country is but 1.6 to 1.
4. The younger men have a higher degree of technical engineering training and in their larger groups compete for technical work under conditions less favorable than those which simultaneously affect the smaller groups of older men.
5. The younger groups of graduates tend to enter the profession under conditions less favorable than those which their predecessors enjoyed.
6. Rapid growth is stimulated in good times through the diffusion of education, but the effect on the total enrolment in the profession is more noticeable at a later period.
7. The number of living engineering graduates of ages 25–34 in 1920 and 1930 exceeded the number of engineers of those ages employed at those dates, and the number of such graduates living to constitute older age groups will exceed the number of engineers of corresponding ages employed in 1930.
8. Though the colleges gave degrees in the past to only two of every five men entered, the rate of graduation as in 1930 was such as to assure a supply of new men ample to supplant the needs arising from death and retirement of a profession at least one-half again as large as it actually was at that date.
9. The number of engineers in practice in 1930, when increased by the annual increments of college graduates, points to a total number of surviving technical engineers from 25 to 64 years of age in 1950 about one-third larger than the number existing in 1930, assuming the rate of education obtaining from 1918 to 1927.
10. The enrolment of national professional societies of engineers and engineering in 1930 was about half the professional group as a whole.
11. Future opportunities for non-college men appear to be limited. Substantially "closed" conditions prevail in the profession. Eliminations have not been effective in restricting numbers nor are they at all likely to effect any stabilization in the next one or two decades.

Geology of Fifteen Mile Falls Development

Design of Dam on Connecticut River Required Extensive Study of the Glaciated Valley

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ENGINEERS and geologists work hand in hand on many construction projects. The assistance which the latter can render perhaps is not as fully appreciated as it should be by many engineers. On the Fifteen Mile Falls Development, a rather extensive geologic investigation was made to determine the position of the buried preglacial gorge of the Connecticut River. The findings influenced both the location and the design of the dam, the power house, and the tailrace at the Lower Falls Development. This current example of cooperation between geologist and engineer is here presented from the geologist's point of view.

EVERY dam site is the product of geologic processes, and the more complete the engineer's understanding of the geologic conditions at the site, the more intelligently and effectively the dam can be planned. Sometimes satisfactory conditions are taken for granted, and later it is found necessary to make expensive alterations in the plans, which could have been prevented by adequate investigation. On the other hand, expensive explorations can sometimes be avoided by a preliminary geologic study. In making borings, much expense can often be saved by laying out the program with an understanding of geologic conditions. The duty of the geologist does not end with ensuring the safety of the dam; he should also endeavor to give information that will aid in its economical construction.

The Fifteen Mile Falls Development on the Connecticut River is not the largest of its kind, neither are the geologic conditions found there the most difficult, but they are typical of many undeveloped dam sites. Although there was no single geologic problem of outstanding importance and difficulty, there were many the correct solution of which affected the plans for the development. An unusually thorough geologic investigation was begun in 1927, a year before construction commenced, and was continued through the construction period. The geologist was consulted on many more problems than is often the case.

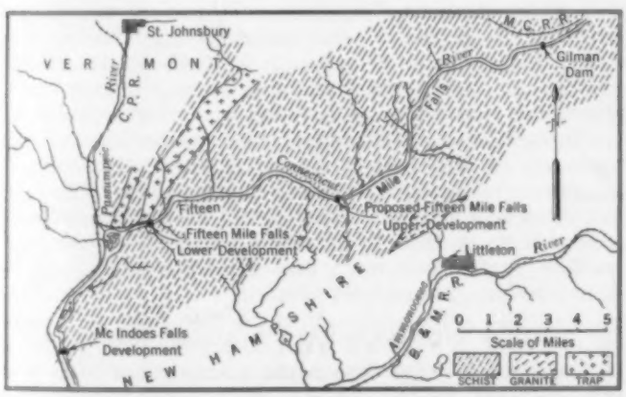

FIG. 1. GENERALIZED GEOLOGY IN VICINITY OF FIFTEEN MILE FALLS

Dam sites in glaciated regions present very different problems from those situated elsewhere. Conditions at the Fifteen Mile Falls Development of the New England Power Association are typical of this glaciated region and illustrate the situation at many dam sites in the northeastern United States and eastern Canada.

In the geologic investigation for the Fifteen Mile Falls Development was included a general geologic study of the valley of the Connecticut River from McIndoes Falls to Gilman in order to get the setting for the practical problems and make certain that no important factors were overlooked. Several alternate sites were examined briefly and found to be inferior. From this study a good idea of the preglacial drainage system was obtained. A comparison of the profile of the present river with the profile which logically would be expected to occur on the preglacial river indicated to the geologist that the old channel was at a considerable depth. Exploration by borings and electrical prospecting proved this to be the case.

Electrical prospecting methods were found to be very useful in determining the depth to bedrock and the approximate character of the overburden. In this investigation they were used for the first time in the study of a foundation. The most satisfactory results were obtained, and the possibility of errors was avoided, when the results were interpreted by the geologist.

Numerous borings were made and test pits dug to determine the nature of the overburden. The locations of the borings, test pits, and electrical determinations were selected in consultation with the geologist in order that they might give the maximum information. Care was taken to obtain unwashed boring samples, and in the case of strata which might carry water under or around the dam, permeability tests were made on such samples. Then, when the geologic arrangement of the formations was known, it was possible to estimate the approximate amount of seepage within reasonable limits. Core borings were made in the bedrock; the holes were subjected to water-pressure tests; and samples of the cores were examined by microscope.

THE FIFTEEN MILE FALLS DEVELOPMENT

Only a brief description of the Fifteen Mile Falls Development will be given here since there is a complete discussion of its engineering features in an article by Clarence R. Bliss, Assoc. M. Am. Soc. C.E., in the *Journal of the Boston Society of Civil Engineers*, September 1932. The Fifteen Mile Falls is a long stretch of rapids with a total drop of 320 ft on the upper Connecticut River, which there forms the boundary between New Hampshire and Vermont. Its relation to nearby towns is shown in Fig. 1. Although these rapids had been studied at different times during the past twenty years, they remained undeveloped until 1928, when the New England Power Association decided upon a development with two dams, the "Lower Dam" at the foot of the rapids and the other eight miles upstream and ten miles below the Gilman Dam. Construction was begun on the

Lower Dam in August 1928, and the plant was put in operation on September 30, 1930. Seven miles downstream from the foot of the Fifteen Mile Falls were the McIndoes Falls, where the river dropped 20 ft over ledges. A dam and power plant previously built at this point by the New England Power Association have been made a part of the Fifteen Mile Falls Development.

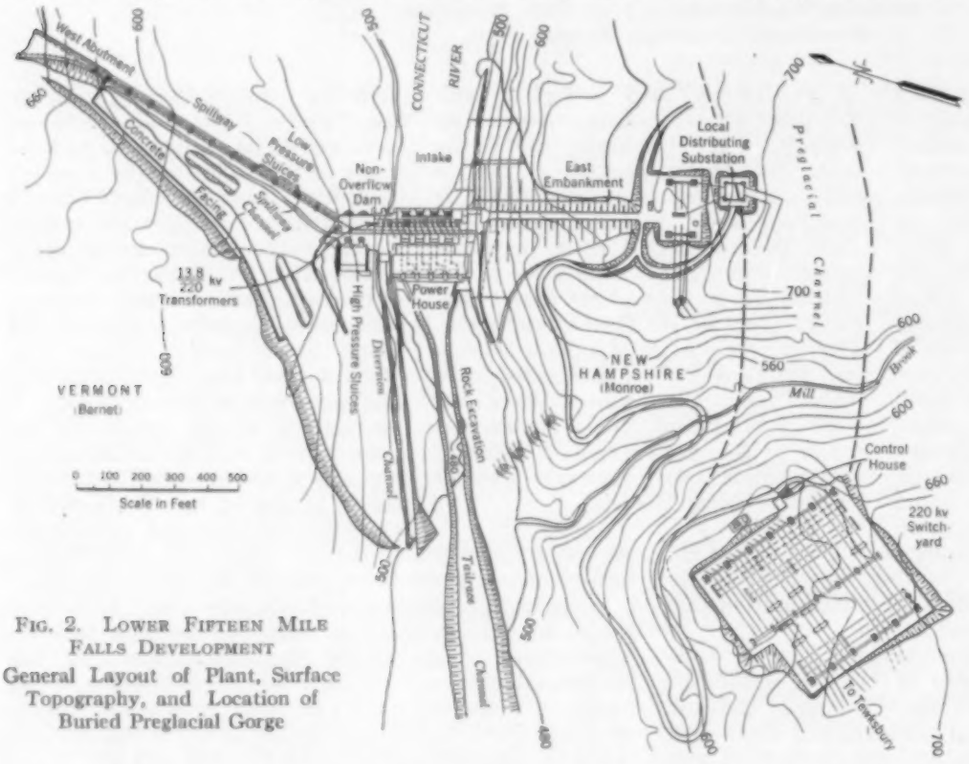

FIG. 2. LOWER FIFTEEN MILE FALLS DEVELOPMENT
General Layout of Plant, Surface Topography, and Location of Buried Preglacial Gorge

Above the Lower Dam the drainage area is 1,650 sq miles, of which 83 sq miles is controlled by storage reservoirs on the upper part of the river. The total length of the dam is 2,000 ft, and its maximum height is 170 ft. The elevation of the crest is 640 ft above sea level, and that of the top of the flashboards, 648 ft. The dam is a concrete gravity structure and is connected with the bluff at the New Hampshire end by an earth embankment. Below the power house, a tailrace giving an additional head of 10 ft was excavated for 6,600 ft, of which 1,400 ft at the upstream end is in rock. The Lower Plant has a generator capacity of 104,000 kw at a head of 170 ft. The layout is shown in Fig. 2.

THE GEOLOGY OF THE FIFTEEN MILE FALLS

Although geologic observations on this region were published more than half a century ago, very little recent work had been done in the neighborhood of the Fifteen Mile Falls until the present practical study was begun in 1927. In fact, not even good topographic maps were available for most of the area. The rocks near the falls are schists, trap, and granite. The schists were formed by the metamorphism of ancient sediments and lavas, and the trap and granite were intruded into the schists. The sediments and lava flows, of which the schists were formed, were originally laid down in nearly horizontal layers, but they have since been folded so that they dip steeply to the southeast. Pyrite is disseminated through parts of the schists and in places has become oxidized, causing decomposition of the rock. In some cases such decay does not show well at the surface; superficial appearances are deceptive.

Deep valleys had been worn in these schists, trap, and granite, and the streams had begun to meander and widen their valleys when the region was uplifted. Thus the streams were enabled to cut down again and entrench their meandering courses in gorges in the floors of their old valleys. The erosion of these gorges was cut short by the advance of the Pleistocene ice sheet, which covered New England for many thousand years. When the ice finally melted, an enormous quantity of debris was deposited, blocking many of the stream channels, changing the drainage systems, and greatly modifying the topography.

At the Fifteen Mile Falls the river drops 320 ft, but there are surprisingly few ledges exposed along its banks in this distance, and at only one place, the Lower Dam, does ledge extend across the river and form both banks. This peculiar scarcity of ledges is due to the fact that there is a deeply buried, winding gorge under the floor of the valley, illustrating the great difference between the topography of the bedrock and that of the surface, especially in the valleys. The gorges that were eroded in the broad bottoms of the valleys are now generally deeply buried under glacial drift. A buried gorge is believed to extend the entire length of the Fifteen Mile Falls. Positive evidence of it has been found at Gilman, at two places between Gilman and the Upper Dam site, at this site, at the Lower Dam, and at McIndoes Falls.

At Gilman the preglacial channel is on the Vermont side of the present river, and at the next two points below it is on the New Hampshire side, but at the Upper Dam, ten miles below, it is on the Vermont side again. At the Lower Dam it is deeply buried under the New Hampshire side, where it is also found at McIndoes Falls. There are other indications of the presence of the buried gorge between these points, showing that it swings from one side of the valley to the other many times. Therefore a dam site may have a buried gorge directly under it or at either side, according to its location. This condition is typical of dam sites in glaciated regions.

CAUSE AND OCCURRENCE OF BURIED GORGES

The buried gorge under the Connecticut Valley is not confined to the Fifteen Mile Falls section. In fact, evidences of a buried preglacial channel are known to exist at many places in the valley above and below Fifteen Mile Falls. Similar conditions have been found on many of the rivers in New England, New York, and the Province of Quebec. In most of the cases mentioned, the preglacial channel is under the present river valley, but in other cases, especially in regions of lower relief, the channel may leave the valley entirely. Such is the case along the Merrimac and Nashua rivers in Massa-

chusetts and on many other rivers. When dams are built on such rivers, there is the possibility that although the dam site itself may be satisfactory, a buried gorge some distance away will allow leakage from the reservoir. Therefore the geologic investigation should include the entire reservoir basin.

In the glaciated regions of the northeast United States, the streams generally are not flowing in their preglacial channels, and often there is little relation between the preglacial and the present drainage system. Even where a stream is now flowing over a ledge, there is usually a buried preglacial channel or gorge nearby. It is essential, therefore, in studying any dam site in the glaciated regions to locate the preglacial channel of the stream and to determine its depth and the nature of the material filling it. The approximate location of the buried channel can usually be learned from a geological study of the vicinity, and sometimes a fair idea of the depth to bedrock can be obtained.

When the ice sheet which covered New England melted away, it left immense quantities of debris or glacial drift. The unsorted and unstratified debris, known as glacial till or boulder clay (a heterogeneous mixture of clay, silt, sand, gravel, cobbles, and boulders), was dropped directly from the ice. The till was deposited as a thin and discontinuous mantle, and is generally found on the hills. In places, however, there are thick deposits of it in the valleys, especially where they are transverse to the direction of the ice movement, as at the Fifteen Mile Falls. Gravel may be preserved in the bottom of the valleys under a layer of till, which also is the case in places at Fifteen Mile Falls.

After the formation of the till, while the ice was still melting, water-laid materials were deposited in streams or glacial lakes. At the dam sites clay, sand, and gravel, which now partly fill the valley, were deposited in a glacial lake. During the retreat of the ice sheet there were cold periods when the ice advanced again and laid down a sheet of boulder clay over the stratified deposits which had previously been washed from the ice sheet.

THE LOWER DAM AND FOUNDATION

At the Lower Dam the river is flowing over ledges at an altitude of 486 ft above sea level. Ledges outcrop at many places up the slope on the Vermont side of the river, but on the New Hampshire side bedrock rises only 10 ft above the river and then extends nearly level under a high bluff of glacial drift for several hundred feet, where it drops off into the preglacial gorge, the bottom of which is 50 ft lower than the bed of the present river and is buried under nearly 300 ft of glacial deposits. This condition is shown in Fig. 3.

At the Lower Dam the layers of schist strike approximately north 30 deg east and dip steeply to the southeast. The river is here flowing from east to west, and the schist layers thus cross it diagonally. Trap was intruded into the schist in a molten condition and forms stringers and lenses parallel to the stratification of the schist. The main mass of trap is to the northeast, and the stringers extend southwesterly from it, some of them dying out in or near the river and some crossing the stream. There are three varieties of schist: massive schist, which is a metamorphosed lava and is somewhat similar to the trap; laminated schist; and slaty schist, which as the name indicates, is a soft, slaty rock.

As regards bedrock, the principal practical problems were: (1) whether there would be serious seepage through the rocks, and whether this would affect the safety of the dam; (2) whether there were faults or other detrimental geologic features; (3) whether the rocks were sufficiently strong to support the dam; (4) selection of a site where there was a maximum amount of trap and massive schist, and where the rocks were in the best condition.

Both the schist and the trap are dense rocks and are impervious where not cracked. The former, because of the intense pressure which it underwent during metamorphism, has a well-developed cleavage parallel to the stratification. The cleavage planes are lines of weakness and may be open fissures, but generally are very fine cracks. In addition, there are more or less irregular joint cracks which cut the trap as well as the

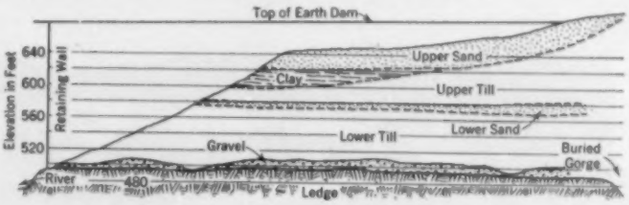

FIG. 3. GEOLOGIC SECTION THROUGH THE NEW HAMPSHIRE BLUFF, ALONG CENTER LINE OF EMBANKMENT, LOWER FIFTEEN MILE FALLS

schist. The cleavage cracks are at an angle of about 45 deg with the line of the dam, making the length of the seepage paths through these cracks longer than would be the case if the cleavage were normal to it.

Further to lengthen the paths which seepage must follow, some grouting was done, with the result that the foundations of the dam are satisfactorily tight. These rocks do not contain any soluble constituents, and therefore a moderate amount of seepage can do no harm. No faults that would affect the dam were found. Both the trap and the massive schist are very strong rocks, but the slaty schist appears weak because of its planes of cleavage. Under the dam, however, where the schist is confined, no movement can take place along these cleavage planes and the schist is amply strong.

As originally planned, the dam was to cross the valley at a point about 200 ft below the point where it was actually built. The location was changed because it was found that upstream there was a ridge consisting of trap and massive schist which would serve as an excellent site for the spillway. They will resist erosion better than the slaty schist, some of which would have been under the spillway at the lower location. Very little excavation was necessary to provide a sound foundation, and the natural rough surface of the rock gave an excellent footing.

In the river bed there is a larger proportion of schist, some of which is of the laminated variety, but it is in sound condition and provides a good foundation. The upturned edges of the layers of schist made a rough surface and also gave an excellent footing, making impossible any sliding of the concrete on the rock or of one layer of rock on another. Very little excavation and no blasting were needed to obtain a fresh surface. Indeed, blasting in the laminated schist is undesirable because it opens the cleavage cracks.

At the New Hampshire end of the dam, the earth embankment rests largely on glacial deposits and was built of materials from these deposits. The geologic problems connected with the earth section of the dam were: (1) to locate the buried gorge; (2) to estimate the possible seepage through this gorge; (3) to study the arrangement, thickness, and continuity of the glacial deposits; and (4) to estimate the possible seepage through different layers of glacial deposits.

The buried gorge, which extends up and down the valley and passes under the river both upstream and downstream, contains preglacial gravel and might form a by-pass for seepage around the dam. The distance along the buried gorge, from the river above the dam to the river below, is more than three-quarters of a mile. Assuming the worst probable conditions, it was estimated that the amount of seepage would be small and harmless. Observation since the reservoir was filled has proved these conclusions correct.

In Fig. 3 it is shown that several different materials

GENERAL VIEW OF THE COMPLETED DEVELOPMENT
Lower Fifteen Mile Falls Dam and Power Plant, Showing Bedrock on the Far (Vermont) Side

compose the New Hampshire bluff, into which the earth dam is tied. On the surface of the bedrock there is usually a layer of gravel which varies greatly in thickness and in character. Above the gravel there is a layer of boulder clay from 50 to 80 ft thick, then a bed of sand varying up to 30 ft in thickness, and next another layer of till varying up to 70 ft in thickness. Above this upper till is a layer of clay, and finally sand to the top of the bluff. The upper till was laid down by a re-advance of the ice, after which a lake, in which clay was deposited, occupied the valley. When this lake was drained, clay was eroded, and sand deposited.

WATER-TIGHTNESS OF RESERVOIR

Many test pits and excavations exposed the layer of gravel overlying the bedrock. On account of the discontinuous nature and variable character of this layer, the final conclusion was that there was no likelihood of dangerous seepage through it. Since construction, very little such seepage has been detected.

Whereas the boulder clay forms a tight and stable foundation for the earth dam, the layer of sand over it might form a possible pathway for seepage. In the sand layers many borings were made; numerous samples were taken; and the average thickness and character of the material, which vary greatly, were determined. After the coefficient of permeability of typical samples was found, an estimate was made of the probable seepage through this sand layer, which showed that under the worst conditions that the information indicated, maximum seepage would be under 3 cu ft per sec. Observations made since the reservoir was filled show that the actual seepage is much less than this limit.

Not only the till overlying the sand, but also the clay which in places covers the upper till, are satisfactorily tight and caused no problem. The upper sand extended only 10 or 15 ft below the proposed reservoir surface, and possible seepage through it was controlled by a moderate extension of the impervious core, forming a cut-off the full length of the embankment. This bluff of various glacial deposits has proved to be a satisfactory abutment for the earth dam.

In the excavation of the tailrace, 6,600 ft long, a knowledge of the exact location of the buried gorge was important since, where the tailrace was over this gorge, excavation was in sand, gravel, and clay and could be handled in the wet by a drag-line. A special study was therefore made of this area, using electrical prospecting methods and borings. A contour map of the bedrock surface was then prepared. It was found that all but the upper part of the tailrace could be located over the gorge, with the result that rock could be avoided in most of the excavation. This was an important factor in deciding whether the tailrace was feasible. By a combination of geologic investigation, electrical prospecting, and borings, more information was obtained in less time and at less expense than would have been possible if borings alone had been used.

Supplies of fine and coarse aggregates for the concrete were needed near the dam. Although suitable sand was found in the glacial deposits, satisfactory gravel could not be obtained on account of the large number of rotten or weak pebbles. The glacial deposits were derived largely from schists, all the varieties of which contained much quartz as well as less resistant minerals. When the schists were broken up and weathered, the less resistant minerals were largely removed, so that the resulting sand consists largely of quartz and is of good quality for use in concrete. With the gravel, however, the case is different, since the pebbles are composed of many grains and contain the less resistant minerals as well as the quartz. There are rotten and slaty pebbles in all the gravels of this vicinity; no deposit of sufficient quantity was found which met the desired standards. For this reason recourse was had to crushed stone for the coarse aggregates.

A large hill containing an enormous quantity of trap rock was found less than a mile from the dam on the Vermont side of the river. Since the rock was very hard and tough, production costs were increased, but an excellent quality of coarse aggregate was obtained. Earth for the embankment was also secured from the glacial deposits, boulder clay being used for the impervious core and gravel from a nearby glacial delta for the pervious outer sections.

The Fifteen Mile Falls Development illustrates the problems which generally arise at dam sites in the eastern part of North America's glaciated region. Of these problems the location of bedrock and the detection of buried gorges are most important. Where an impervious cut-off is not carried to bedrock, a knowledge of the arrangement and permeability of the glacial deposits is essential. At the Fifteen Mile Falls, bedrock conditions were satisfactory, but such is not always the case. Sometimes serious problems of this sort arise.

The work was carried out for the Grafton Power Company, part of the New England Power Association, by the Connecticut River Development Company as constructors, with whom were associated the construction organization of the Frazer-Brace Engineering Company, Inc. All designs and plans for development were made by the New England Power Construction Company. Albert S. Crane, M. Am. Soc. C.E., and Charles T. Main, Inc., of Boston, were retained as consulting engineers, and I was the consulting geologist. The electrical prospecting work was carried out by Schlumberger Electrical Prospecting Methods.

Traffic Over the George Washington Bridge

Experience During Two Years of Operation Indicates Effectiveness of Approach Facilities

By BILLINGS WILSON

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THREE things should be accomplished by a highway bridge and its approaches. First, they should provide safe transit for patrons; second, develop maximum capacity on both main deck and approaches; and third, handle traffic expeditiously, with minimum delay. All these considerations of course were given careful attention in the design of the George Washington Bridge and its approaches. Since difficult operating problems and deficiencies in design only become apparent when traffic is sufficient to cause congestion, the experience to date has been uniformly satisfactory.

OPENED for traffic on October 25, 1931, the George Washington Bridge has now been in operation a little more than two years. In this article, Mr. Wilson tells how the yearly traffic of over five million vehicles is handled and relates how and to what extent the approaches and toll collection facilities have fulfilled their purpose. Although some peak days have tested the facilities provided, only a few changes in the original design have been found necessary or desirable. The article will prove of interest to operators of similar structures and may be helpful to engineers who are planning bridge approach and toll collection facilities.

Opened in the midst of the most severe business depression of modern times, the bridge has never been used to anything like its capacity, with the exception of the opening day and the two following Sundays. The average daily traffic in 1932 was 15,096 vehicles. The traffic for the first 24 hr of operation was 54,336 vehicles. The following Sunday, November 1, 1931, it was 46,899 vehicles; and a week later, November 8, 1931, it was 45,627 vehicles. The estimated daily capacity is approximately 90,000.

Two roadways are provided on the bridge itself, each with a width of 28 ft 9 in. to accommodate two traffic lanes. Experience during the opening week showed that when the traffic was made up entirely of pleasure cars, it automatically arranged itself in three parallel lines on each roadway; but that when a bus or truck appeared the capacity was reduced to two lanes.

A speed limit of 30 miles per hr, with reasonable tolerance, has proved effective in keeping accidents down to the minimum. Traffic has moved in an orderly manner, with only seven minor collisions on the bridge itself during the entire year of 1932. One fatal accident occurred on the New York approach, when a motorcyclist hit a dividing curb between two roadways.

On the New Jersey end, the approaches have proved ideal and ample for all conditions. The system of right-hand turns and no cross traffic movement has resulted in automatic routing, requiring no control officers outside the toll area. All the toll booths are at the New Jersey end of the bridge. In the beginning the wide plaza both east and west of these booths tempted motorists to cross it diagonally and to make 180-deg turns in an effort to return to the New York side before reaching the booths. This deficiency was quickly corrected by placing a line of stanchions, with

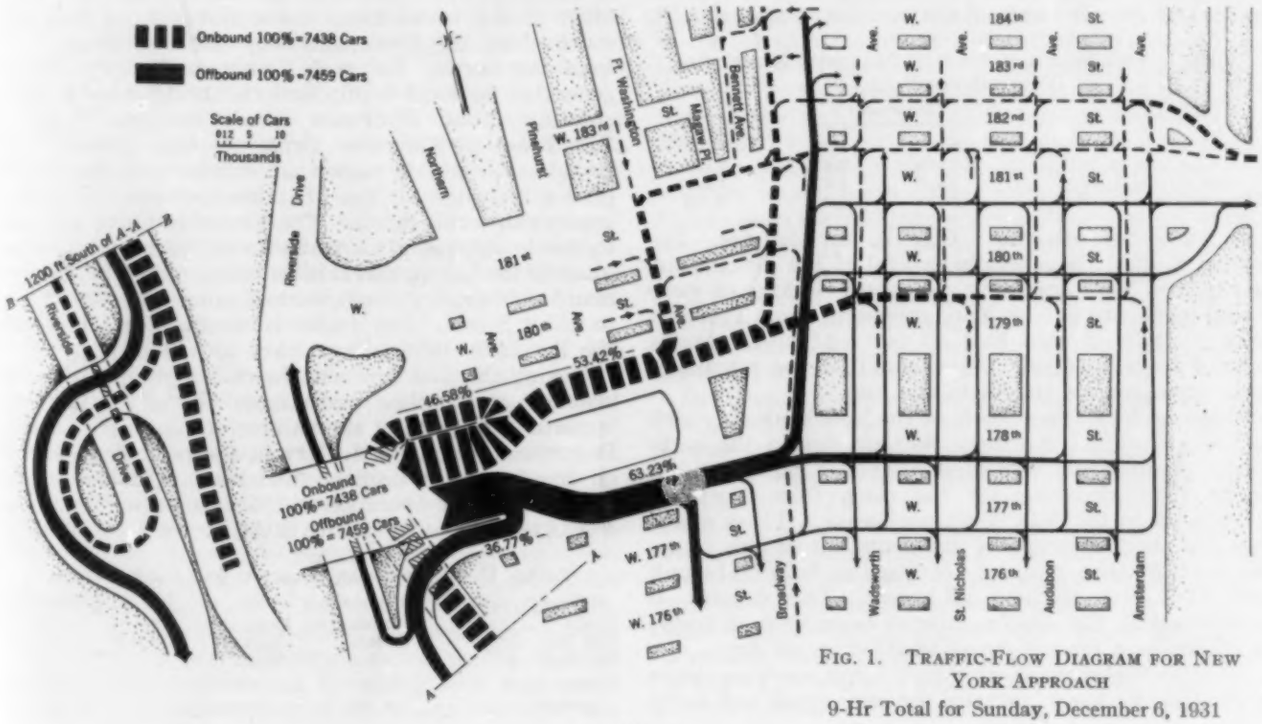

FIG. 1. TRAFFIC-FLOW DIAGRAM FOR NEW YORK APPROACH
9-Hr Total for Sunday, December 6, 1931

red lights, down the center line of the plaza. A similar situation on Lemoine Avenue, within the zone of the bridge approach, was corrected by the Fort Lee Police Department in the same manner. The wide areas adjacent to the toll booths have facilitated snow removal.

In its present initial stage of construction, the New York approach is the restrictive influence on the capacity of the bridge. Happily, the difference in capacity between these approaches and the bridge deck is not material. The bottle neck now lies at Northern Avenue, at the bottom of a sag between two opposing ramps, where traffic to and from Riverside Drive is required to make a 180-deg turn on a compensated 4 per cent grade. A number of rear-end collisions and sideswipes occurred at this point in 1932.

A 9-hr clocking made on the New York approach on November 8, 1931, two weeks after the bridge was opened, showed that 46 per cent of the westbound traffic entered the bridge from Riverside Drive; that 38 per cent left it by that thoroughfare; and tnat the remainder in each direction moved via surface streets on Fort Washington Heights. These percentages may be compared with the predictions of 28 per cent westbound and 28 per cent eastbound made before the bridge was opened. A similar clocking on Sunday, December 6, 1931, gave practically the same results as the previous one, but the peak-hour traffic showed an increase to 48 per cent in the on-bound traffic from Riverside Drive, and 39 per cent in that off-bound to the drive. A Friday clocking made about the same period showed 50 per cent of the westbound traffic coming from Riverside Drive and 39 per cent of the eastbound going to it.

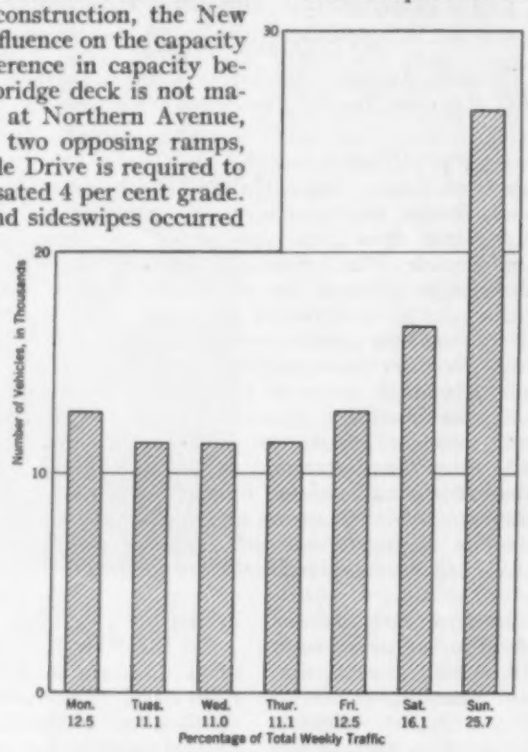

FIG. 2. AVERAGE DAILY TRAFFIC FOR YEAR ENDING MARCH 31, 1933 Over the George Washington Bridge

TABLE I. TOLL-BOOTH RECORD OF MAXIMUM NUMBER OF VEHICLES PER HOUR

DATE	DIRECTION		TOTAL
	East	West	
Sunday, Oct. 25, 1931	3,004	2,673	5,677
Sunday, Nov. 1, 1931	2,920	2,829	5,749
Sunday, Nov. 8, 1931	3,779	2,997	6,776

The traffic-flow diagram (Fig. 1), for Sunday, December 6, 1931, is generally typical of the distribution on the New York approach. A recent clocking of westbound traffic at the New York approach, made Tuesday, May 9, 1933, showed that 45 per cent of the traffic entered from Riverside Drive and that the remainder came from surface streets to the east.

Stop-watch clockings made on the New York approach in the vicinity of Northern Avenue during the early weeks of operation indicated a greater on-bound capacity than off-bound for the ramp from Northern Avenue up to the New York anchorage. These clockings, for short intervals of maximum use of this ramp, showed capacities of about 4,000 cars an hour on-bound, and 3,600 cars an hour off-bound. This density, if maintained for the same number of hours as peak traffic at the Holland Tunnel, equals 90,000 cars per day.

The phenomenon of an "up" ramp carrying more traffic than a "down" ramp of the same grade and width has been frequently observed in connection with pedestrian ramps in large passenger terminals. It is undoubtedly due to the greater caution exercised by persons proceeding downhill.

For comparison with the observed ramp capacities for short intervals, the maximum hourly records of vehicles passing toll booths on certain peak days are shown in Table I.

Experience on the New York approach in the vicinity of Northern Avenue has demonstrated the futility of expecting motorists to follow directional signs and traffic lines unless a traffic officer is on duty in the immediate vicinity. Ninety-nine motorists out of one hundred will proceed in accordance with the desires of the bridge operators, but the one-hundredth will do something contrary to all directional signs and recognized traffic principles and cause a snarl or jam that will require several minutes to straighten out and thus reduce the traffic capacity of the bridge. Nowhere is this more noticeable than in connection with the 180-deg turns at Northern Avenue, even after the parapet walls were flared to increase the width at the entrance.

East of Northern Avenue the New York approach has been entirely satisfactory, and ample for all bridge traffic even on the heaviest days. This is true also of the ramps leading down to Riverside Drive. It is interesting to note in connection with the Riverside Drive ramps that four-fifths of the traffic using them moves to or from the south along the Drive, and only one-fifth moves to or from the north. Riverside Drive north of the bridge generates no local traffic, and the bridge-bound traffic entering it at Dyckman Street has the choice of Broadway or Riverside Drive at that point. The Broadway route is somewhat shorter and has easier grades although it has the disadvantages of trolley tracks and traffic lights. The Riverside Drive entrance to the bridge ramp for traffic from the north is so far south of the bridge that it is confusing to most motorists, many of whom try to use the exit ramp or the city ramp to 181st Street. For traffic from the south, however, the Riverside Drive ramps have proved ideal.

During the first few months of bridge operation the problem of handling pedestrians proved to be quite important, because of the volume of "curiosity" traffic. Pedestrian traffic, particulary in the peak demand and on Sundays, has declined materially. Sunday traffic for three days of operation in 1931, soon after the bridge was opened, compared with 1933, is given in Table II.

TABLE II. PEDESTRIAN TRAFFIC ON PEAK SUNDAYS

1931	PEDESTRIANS	1933	PEDESTRIANS
Nov. 1	22,635	April 23	2,217
Nov. 8	25,648	April 30	2,489
Nov. 15	12,577	May 7	2,555
Total	60,860	Total	7,261
Average	20,287	Average	2,420

Week-day pedestrian traffic in 1931 amounted to about 5 per cent of the Sunday traffic, whereas in 1933 it was about 12 per cent of that on Sunday.

The pedestrian toll charge is 10 cents and is now collected with subway-type turnstiles on both approaches. With the aid of such improvements as wider stairs and aisles, it is now possible to handle the heaviest Sunday pedestrian traffic with but 6 collectors, one at each end of the bridge for each shift; whereas formerly 16 were required on a busy Sunday.

Pedestrian access to the bridge in New Jersey is by a sidewalk from Hudson Terrace and, being on an easy grade, is very satisfactory. On the New York side, again due to the necessities of the initial stage of construction, access is by long flights of stairs leading up from Haven Avenue, and these stairs constitute a toilsome journey to older patrons. The lack of sidewalks along the Riverside Drive ramps has resulted in the use of the roadway by pedestrians, thereby creating an undesirable traffic condition. These ramps were not designed for pedestrians, since other facilities are provided for them in the vicinity. The public is quick to take advantage of short cuts, however, and the vehicular ramps have proved sufficiently intriguing to attract not only regular pedestrians but nursemaids with baby carriages, small boys on sleds and bicycles, and even dogs. These ramps are under the jurisdiction of the New York City police; the bridge police do not have control over them.

present enclosures at the ends, so that each collector would have a separate enclosed area facing his lane.

The overhead clearance of the toll lane canopy and the lighting arrangements, both under the canopy and on the wide plaza areas, have proved entirely satisfactory.

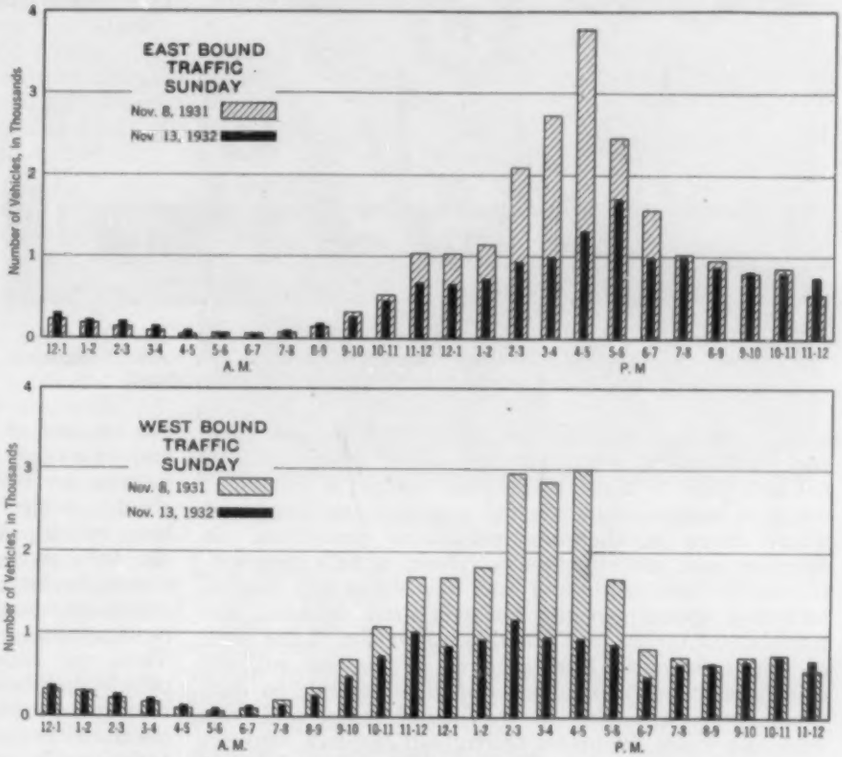

FIG. 3. HOURLY FLUCTUATIONS IN VEHICULAR TRAFFIC OVER THE GEORGE WASHINGTON BRIDGE
A Sunday in 1931 Compared with a Sunday in 1932

One of the most interesting features of a toll bridge is the collection system. It is here that the motorist comes in contact with the operating organization, and it is here that traffic must be handled courteously and expeditiously in order to preserve amicable relations with the public and avoid delays that will restrict the capacity of the bridge.

With the exception that the 18-ft roadway beween toll islands is not sufficiently wide for two traffic lanes, the arrangement of the toll booths and toll lanes on the George Washington Bridge has proved generally satisfactory. In future designs, this width between toll islands should be increased to 20 ft at least, and preferably to 22 ft. A 7-ft width is suggested for the toll islands where two collectors occupy the same island, and work back to back.

To accommodate side overhang of vehicles, the clearance between the face of the curb and the face of the toll booth should be increased from 10 in. to about 20 in. On the average of once a month a large van, or similar type of vehicle, scrapes the face of a toll booth because of its nearness to the curb.

On each toll island the arrangement of the collectors' stations has somewhat restricted the working space because of the necessity of installing fronts of removable steel and glass panels to provide additional protection for collectors during severe weather. In future designs, instead of having the two collectors stand back to back in the center of the toll island, facing their respective lanes, consideration should be given to a permanent enclosure of the center part of the island instead of the

Some difficulty is found in distributing traffic uniformly to the toll lanes, when several lanes are open. The motorists have a tendency to follow a line of cars to one toll lane and to overlook entirely an adjacent open toll lane, and thus to delay unnecessarily their passage through the toll area. Distribution can be secured effectively by police supervision, but the latter is expensive, and a need is therefore indicated for some electric signs or other devices which will show motorists, when they are several hundred feet from the toll booths, that certain lanes are open, and which will guide them to these lanes. If effective signs can be developed, it would be desirable in future installations to work them into the architectural treatment of the toll structures wherever the motorist is confronted with a wide choice of toll booths. Removable roadway barriers or gates, painted black and white, are essential to mark all closed lanes.

Developed after exhaustive experiments and tests by the Port Authority staff, the various toll-collecting devices have fully lived up to expectations. The operating department is pleased with the system and its performance. The fare register, vehicle-counting treadles, overhead tariff signs, and checkers' indicator boards cost approximately $5,000 per lane, installed. The object of so much collection and checking equipment is to encourage honesty among the collectors rather than to catch dishonest employees; although in fortunately rare instances it has admirably performed the latter function. It takes time and money to develop a courteous and efficient toll collector, and it pays the

operator to keep these employees as long as possible. Such men are the real salesmen for the management, being the persons in direct contact with patrons. It is therefore felt that extra expenditure for equipment is justified if it reduces temptation, discourages petty transgressions, and promotes honesty.

All tolls are collected at the New Jersey end of the bridge. Such a system has decided advantages from the standpoints of administration and efficiency. In the first place, it consolidates cash receipts at one point, where a maximum number of men are employed and where there is therefore maximum protection. It requires only one supervisory officer, a tolls sergeant, to handle both eastbound and westbound toll booths, including special permits for over-sized vehicles, disputes about tariffs, and general observation of the work of the collectors. Furthermore, by having all toll collectors at one central location it is possible to shift them from eastbound to westbound lanes, and vice versa, as traffic fluctuates throughout the day, without the necessity for transferring men from one end of the bridge to the other. This advantage has frequently been apparent when a sudden surge of traffic, due to some spectacular occurrence on one side of the river or the other, attracts a crowd in one direction.

TOLL BOOTHS AT MAIN TOLL PLAZA, FORT LEE, N.J.
Toll Area Is Flood-Lighted from Four Towers, Two of Which Are Shown. Signs at Each Lane Show Classification Number as Toll Is Registered

Tickets, which are undesirable for many reasons, are not required. The sale of tickets is a slower operation at the toll booths; their use requires an extra man or men to collect them; there is the constant risk that they will find their way back to collectors' hands for re-sale; if not collected, they are thrown away by the patrons and litter up the property in an unsightly manner; and the cost of paper for them alone amounts to several thousand dollars a year on a busy crossing.

TABLE III. TOLL-BOOTH PERFORMANCE RECORD FOR SUNDAY, NOVEMBER 8, 1931
In Terms of Cars per Booth

HOURLY PERIOD	EASTBOUND		WESTBOUND	
	Average	Maximum	Average	Maximum
2:00 to 3:00 p.m.	417	560	424	457
3:00 to 4:00 p.m.	455	487	409	464
4:00 to 5:00 p.m.	498	604	428	489
5:00 to 6:00 p.m.	351	422	239	312

Approximately 50 per cent of the patrons, knowing the toll rates in advance, hand the proper change to the collector, without stopping. That the toll system in use is fast is indicated by the performance records at the toll booths. For example, on Sunday, November 8, 1931, for a 4-hr period, when traffic was heavy in both directions, the performance indicated in Table III was attained at the booths. This table indicates that for several hours, when traffic was available in sufficient volume, collectors averaged over 400 vehicles per lane per hour. One man exceeded 600 cars, that is, 10 cars per minute passed his toll register for one hour.

By virtue of being faster, this system affords great capacity. A maximum of seven toll lanes in one direction will feed the deck of the bridge as fast as the roadways and the New York approach can take the traffic. This means approximately 500 cars per hour per toll lane when the three bridge lanes in each direction are used at full capacity. This latter condition, however, has only obtained during the first three weeks after the bridge was opened. Assuming for each bridge lane a capacity of 1,200 cars per hour and for each toll lane an average capacity of 400 cars per hour, indicates the desirability, from the standpoint of design and construction, of providing at least three toll lanes for each active bridge lane.

The toll system in use provides many checks on the work of the toll collector. The patron is able to observe the amount of the fare registered, if he is interested, and experience indicates that a sufficient number of patrons are interested to make this feature a valuable check. Secondly, the overhead signs above each toll lane, which publicly display the individual tolls, enable the tolls sergeant, patrol sergeant, captain of traffic, superintendent, or any other person or persons concerned to constantly observe whether or not the correct registrations are being made for each type of vehicle. Thus, the collectors never know who, or how many people, may be observing their work. Thirdly, checkers' indicator boards, located at four different points on the premises, permit the superintendent, tellers, and auditor's men to make surprise checks on the work of any or all collectors without being observed. Lastly, the vehicle treadles in each toll lane accurately record the passage of all vehicles, so that the collector cannot omit recording his receipts on the register without detection.

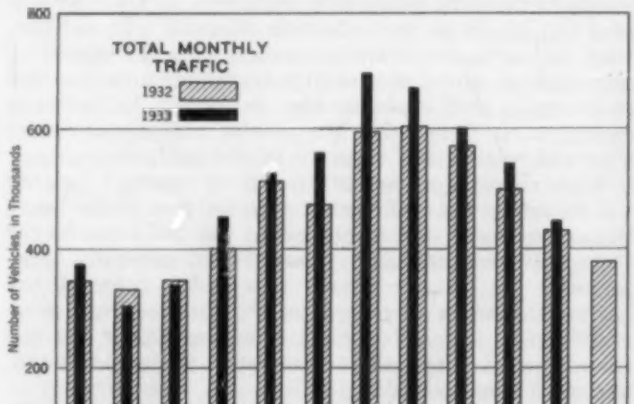

FIG. 4. MONTHLY VARIATION IN TRAFFIC OVER THE GEORGE WASHINGTON BRIDGE
The Year 1932, Compared with 1933

These vehicle treadles are perhaps the key to the whole system in that, in effect, they supplant ticket collectors and are more nearly infallible and less costly than an extra man. They are of a new design developed

by the operating department, and have a proved accuracy in excess of 99.9 per cent after a year's use. This accuracy rating would be even higher were it not for the fact that the treadle cannot prevent collectors from making errors in registration, which are included in arriving at the rating mentioned. These vehicle treadles consist of rubber pads approximately 12 in. wide by 10 ft long, containing four parallel metal contacts, closed in rotation by the passage of a rolling load. A train of relays, actuated by these contacts in sequence, records a single impulse, for a single axle, on an electric counter in the fare register. A special grade of rubber was selected for these treadles to ensure long life. The roadway paving for a distance of 3 ft on each side of each treadle is constructed of smooth armored concrete, and the far edge of the treadle is elevated approximately $\frac{1}{2}$ in. to prevent a fast-moving wheel from jumping over any of the four contacts.

In order to minimize surplus axle counts, due to vehicles running past the toll booths and then backing up, the treadles were placed about 18 ft beyond the fare register. If a vehicle does run past a treadle, and then backs up to the booth, the collector summons the tolls sergeant immediately and gets a clearance for the extra impulse, which enables the auditor to check the records.

All the toll collectors' stations and the cashier's office are equipped with emergency alarm devices, and weekly drills are held. When the alarm sounds, all traffic men and collectors stop all vehicles immediately, in all lanes, until the source of the alarm is identified and properly handled. All uniformed men are armed.

TRAFFIC FLUCTUATIONS BY HOURS, WEEKS, AND MONTHS

One of the greatest difficulties confronting a toll-bridge operator is the wide fluctuations in volume of hourly, week-day, and monthly traffic. Experience with Sunday traffic shows that nearly 50 per cent is handled between 4:00 p.m. and midnight.

In the year 1932, approximately 91 per cent of the traffic on the George Washington Bridge consisted of passenger cars. Available data on the license plates by states indicates approximately 90 per cent to be residents of the states of New York and New Jersey and for the most part presumably familiar with the routes to the bridge. Because such a large proportion of the traffic is local, it is to be expected that on Sundays and holidays it will be much greater than on week days. This is evidenced by the data in Fig. 2, which give the average traffic on each of the seven days of the week for a period of 52 weeks.

It shows that Saturday and Sunday traffic represents approximately 42 per cent of the week's total, and that Sunday traffic is more than double that on any week day except Saturday. Accordingly, the bridge operator must have many more toll collectors and traffic men on duty on Saturdays and Sundays than on other days. This is arranged normally by requiring all uniformed men to work Sundays and concentrating as many as possible of their days off in the first five days of the week.

In Fig. 3 the fluctuation of traffic over different hours of the day is illustrated. It shows why only 2 collectors are needed during certain hours of the day and as many as 12 at other times. It also portrays the abnormally high traffic on Sunday, November 8, 1931, all occurring within the same few hours, in both directions, indicating clearly that it was curiosity traffic resulting from the opening of the bridge two weeks previously. The situation in 1932, also shown on this chart, is more nearly typical of present-day conditions.

Not only does traffic vary hourly and weekly, but also monthly, there being as much as an 80 per cent increase for the maximum month over the minimum month, as evidenced by the record in Fig. 4 for 1932–1933. The month of August 1932 was 181 per cent

NEW YORK APPROACH TO THE GEORGE WASHINGTON BRIDGE

of February 1932. The total traffic for 1932 was 5,509,761 vehicles.

Since most of the traffic increase in the summer months occurs on week-ends, it is more economical to handle it by engaging special Sunday toll collectors from among the clerical force in other departments, who are usually on a five-day week during the summer months. In this manner it has been possible to obtain a high type of individual, with established allegiance to the organization, who is usually glad to make the extra day's pay. A larger force than would normally be needed was organized for the opening of the bridge in order to take care of what it was known would be extraordinarily heavy initial traffic. The winter months that ensued were an ideal training period for this force, which thus was made generally adequate to take care of the heavy traffic in the following summer. Increased efficiency and normal deletions have since made it possible to reduce the initial force to meet prevailing subnormal traffic conditions, as shown in Table IV.

TABLE IV. OPERATING PERSONNEL REQUIRED

PERSONNEL	INITIALLY AUTHORIZED	AT PRESENT AUTHORIZED	ON DUTY ON A TYPICAL WEEK DAY
Supervisors, cashiers, and clerical workers	9	8	6
Toll collectors and police	67	49	35
Maintenance personnel	14	13	12
Total	90	70	53

On all Port of New York Authority bridges the operating department has adhered to the policy of a single uniformed force to handle both toll collections and traffic control. These men are given the title of "bridgeman" and have the legal status of peace officers and constables in their respective states. They are used interchangeably as toll collectors and traffic men, depending upon the needs of the situation from day to day and from hour to hour. When not engaged in either of these duties, they may be employed for general cleaning and maintenance work. This flexibility is desirable from the standpoint of efficiency.

Differential Manometers Investigated

Studies of the Surface Tension of Liquids and Capillary Attraction in Tubes

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RESPECTIVELY, WITH THE AGRICULTURAL EXPERIMENT STATION, MONTANA STATE COLLEGE, BOZEMAN; AND GRADUATE STUDENT AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA

SINCE differential pressure gages have been used in hydraulic experimentation in which a high degree of multiplication was desired, the question of their accuracy for such use is important. In a thesis study of this type of gage at Cornell University, Messrs. Eagle and Wilson determined that a number of characteristics inherent in the tubes and liquids used cause very unsatisfactory results. An analysis of the defects of such apparatus has been abstracted from the complete thesis, which is on file in the Engineering Societies Library. The results of this study, a valuable addition to the engineer's knowledge of this type of gage, are here presented in the hope that they will save both time and effort for those who are engaged in hydraulic experimentation.

AS stated in most textbooks of physics and elementary hydraulics, the theory of the differential manometer, or U-tube gage, implies that practically any degree of sensitivity can be obtained by selecting the proper liquids. An investigation of engineering literature reveals that such instruments have been used for refined measurements at times with apparent success. We made an attempt to construct and demonstrate the practicability of such a gage, giving a multiplication of 50. It was found that the magnitude of the force due to surface tension at the liquid interfaces in the gage tubes was so large that the gage readings did not accurately indicate the pressure. Consequently the purpose of the investigation was changed to a study of the behavior of differential manometers.

THEORY OF THE U-TUBE GAGE

The following fundamental expression, derived directly from elementary principles of hydrostatics, makes possible the calculation of the pressure difference by observing the length of the balanced liquid columns:

$$D = \frac{w}{w - w_h}(h_1 - h_2) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [1]$$

Referring to Fig. 1, h_1 is the distance of the liquid surface in one reservoir from the datum OO'; h_2 is the corresponding distance for the liquid in the other reservoir; w is the specific gravity of the liquid in the reservoirs, which was water in all this work; D is the difference in length of the balanced columns of liquids; and w_h is the specific gravity of the liquid used in conjunction with the water, and called hereafter the secondary liquid. The cross-sectional areas of the reservoirs A and B, and of the gage tubes, were determined. Eight gages, differing principally in diameter of tubes, were employed. The secondary liquids used were phenetole, kerosene, carbon tetrachloride, and solutions of the last two.

In the conduct of the investigation, the fundamental operations were the creation of a known difference of head and observation of the corresponding gage reading. The multiplication factor was then computed and compared with the quantity $\frac{w}{w - w_h}$ of Equation 1. The water levels in the two reservoirs, of known cross-sectional area, were first brought to a common level, and then a difference of head was created by adding an accurately measured volume of water to one of the reservoirs. The result was a rise in the water level in each reservoir. If the rise in the reservoir to which the water was added is called H and that in the other reservoir x, the resulting difference is $H-x$, and from Equation 1 is obtained

$$D = \frac{w - w_a}{w - w_h}(H - x) \quad . \quad . \quad [2]$$

which includes the refinement, not included in Equation 1, of considering the volume of air of specific gravity w_a and height $H - x$.

If a is the inside area of the tube; A, the area of the reservoir; and D, the length of the balanced liquid columns after the addition of the water, it follows that

$$x = \frac{a}{A} \cdot \frac{D}{2} \quad . \quad . \quad . \quad . \quad [3]$$

provided that D was zero when the water in the reservoirs was at a common level.

If the volume of water added is called V and if the areas of the two reservoirs, as well as those of the gage tubes, are assumed to be identical, it follows that

$$H + x = \frac{V}{A} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [4]$$

CONDUCTING THE EXPERIMENTAL RUNS

For convenience, certain conventions were followed in designating the signs of the readings, D, and the volumes of water, V. Water added to reservoir A was considered positive; that added to B, negative. When the meniscus in the left tube stood higher than that in the right, and the secondary liquid was lighter than water, the reading D was positive. When the secondary liquid was heavier than water, the converse was true.

A complete run consisted of observations of D, of temperature, and of time, and a description of the form of the menisci, starting with the water in the reservoirs at a common level, continuing after each addition of water throughout a suitable range of values of D, and ending with ΣV equal to zero.

The experimentation consisted of 40 runs on two-liquid gages, two runs on three-liquid gages, and 13 determinations of surface tension. A supple-

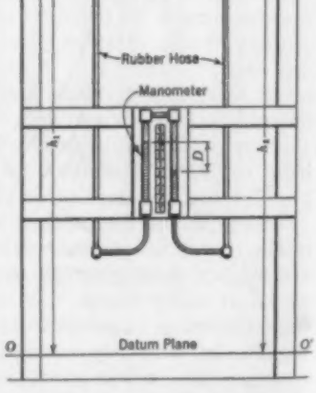


FIG. 1. SKETCH OF APPARATUS USED IN MANOMETER INVESTIGATION

mentary study of surface tension by the capillary-rise method was made in order to interpret the results obtained with the gages.

In recording the data, the observed reading of the gage was termed D, and the value calculated from Equation 2 was called d. The correction, C, was found thus:

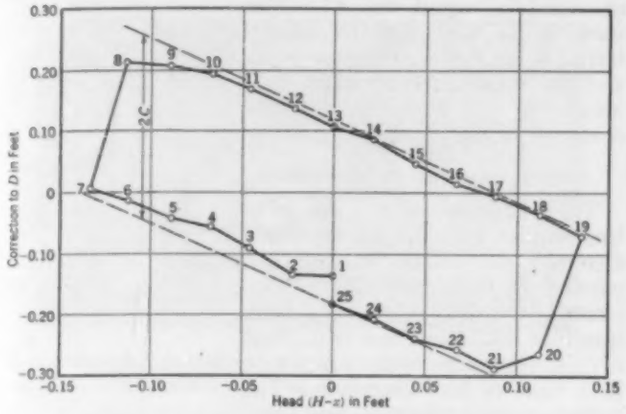


FIG. 2. SAMPLE RUN NO. 30 PLOTTED

Gage Tube 4.2 mm in Diameter; Solution with Specific Gravity of Approximately 1.1. Slope of Line in Dashes Gives Multiplication Factor of Gage

$$C = d - D \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [5]$$

The quantity D', the difference between successive values of D, was computed. In a similar way, d' was obtained. The summation of the values of D' was called K. The quantity $\frac{w - w_s}{w - w_k}$ of Equation 2, was termed M, or the multiplication factor.

ANALYZING THE DATA

Plottings of two types were used in the analysis of the runs. In the first type, the quantity $H - x$ was plotted as the abscissa, and D as the ordinate. The slope of the resulting line should then be M, or the multiplication factor of the gage. The points for each run were found to plot in two very nearly parallel straight lines with a slope practically equal to M, as computed from Equation 2. In the second type of plotting, $H - x$ was again plotted as the abscissa; and the correction, C, as computed from Equation 5, was plotted as the ordinate. A typical plotting of the first type is shown in Fig. 2, and the same data plotted by the second method are given in Fig. 3, termed a correction chart. The exaggeration of detail can readily be seen.

In Fig. 4 (a), the line fg represents the locus of the points which would result from the use of the values of the calculated gage reading, d, and the line kh is drawn through the plotted values of D. The lines rs and OO' in Fig. 4 (b) correspond respectively to kh and fg in Fig. 4 (a). The distance C is common to both types of plotting. In Fig. 4(a) the actual multiplication is equal to $\frac{D}{P}$, and the theoretical multiplication, M is equal to $\frac{C + D}{P}$. The actual multiplication may be obtained directly from the correction chart by use of the equation:

$$\frac{D}{P} = \frac{C + D}{P} - \frac{C}{P} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [6]$$

or in other words, the actual multiplication is equal to the theoretical multiplication minus the tangent of B.

DISTURBING EFFECT OF SURFACE TENSION

In Fig. 5 is shown the formation of menisci in a gage. Since the force at the interface acts in the direction of the arrows, the reading D will be larger than the value calculated by Equations 1 and 2. Points 8 to 13, inclusive, in Fig. 2, represent such readings. The arrows, v and w, show the direction of motion of the liquid in this case. A reversal of the direction of motion would result in readings such as are represented by points 1 to 7, inclusive, in Fig. 2. Hence the vertical distance between the two dashed lines, $2C$, is a measure of the force at the interfaces.

TABLE I. FORCES ACTING AT INTERFACES OF MANOMETER LIQUIDS

RUN	LIQUID	DIAMETER OF TUBE In mm	$2C$ In Feet	$\frac{2C}{h}$
7	Kerosene	21.80	0.032	3.15
10	Kerosene	21.80	0.030	2.85
13	Kerosene	8.10	0.053	1.51
14	Kerosene	11.64	0.012	0.50
39	Kerosene	10.62	0.033	1.29
17	Kerosene	4.20	0.096	1.30
18	Kerosene	4.20	0.099	1.57
20	Kerosene	4.20	0.119	1.81
22	Kerosene	4.20	0.089	1.39
25	Carbon tetrachloride	11.64	0.006	1.03
26	Carbon tetrachloride	4.20	0.017	1.04
28	110*	25.00	0.041	2.60
29	110*	11.64	0.072	2.12
30	110*	4.20	0.300	2.72
31	90*	25.00	0.043	3.07
32	90*	4.20	0.245	3.07
33	90*	8.10	0.169	3.84
40	90*	10.62	0.074	2.17
35	105*	8.10	0.357	3.63
37	104*	47.00	0.057	3.38

* Solutions of carbon tetrachloride and kerosene, designated by numbers approximately equal to their specific gravity multiplied by 100.

In the supplementary work on surface tension the height h, to which the various liquids would rise in a capillary tube, was determined for many of the runs. If the tension at each meniscus in a gage were such that it would cause a rise of h in a tube of given diameter, the distance $2C$ would be equal to $4h$. As shown in Table I, the values range from 0.5 to 3.84 and never exceed the limit of 4.

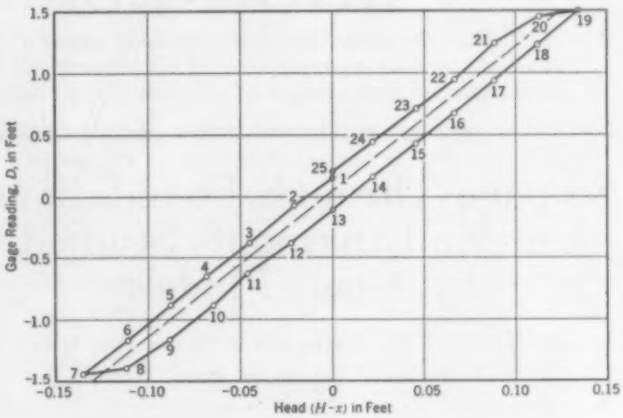


FIG. 3. CORRECTION CHART FOR SAMPLE RUN NO. 30

If the menisci formed in identically the same way for each reading, the correction, C, could be applied and good results obtained. Equation 2 might then be written thus:

$$D = \frac{w - w_a}{w - w_k} [(H - x) + T] \quad . \quad . \quad . \quad . \quad . \quad [7]$$

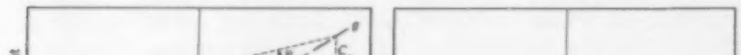
in which $C = MT$.

However, both the work with the gages and the supplementary study of surface tension showed that the shape of the menisci and the force at the interfaces vary widely.

TABLE II. STUDIES OF CAPILLARY RISE

LIQUID	SPECIFIC GRAVITY	FORCE AT INTERFACE IN DYNES PER CENTIMETER	
		Air–Liquid	Water–Liquid
90*	0.908	26.2	25.2
94*	0.942	22.4	24.2
102*	1.022	28.5	31.1
Kerosene	0.819	25.4	31.8
Carbon tetrachloride	1.653	25.6	33.1
Water	1.000	72.2	....
			Kerosene-Alcohol
Alcohol	0.790	21.2	2.53

* Solutions of carbon tetrachloride and kerosene, designated by numbers approximately equal to their specific gravity multiplied by 100.



(*a*) Plot of Run (*b*) Correction Chart

FIG. 4. GRAPHICAL DETERMINATION OF CORRECTION TO MANOMETER READINGS

It was found that as small changes of $H - x$ were produced, the form of the menisci changed slowly from convex in one direction to convex in the opposite direction. During this time, D' was either zero or very small compared to d', indicating that the sign of T in Equation 7 did not change instantly when the direction of motion of the liquids changed. When the shape of the menisci had become completely reversed, D' again became approximately equal to d'. This variation in the forces at the interfacial surface in the gage tubes and the comparatively large magnitude of the forces destroy the accuracy of the two-liquid gage.

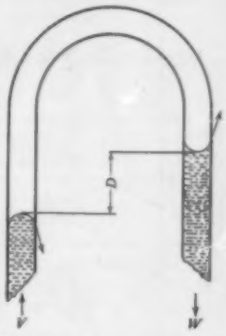


FIG. 5. FORMATION OF MENISCI IN A GAGE

THREE-LIQUID MANOMETERS

The possibility of the use of a three-liquid gage, using kerosene, alcohol, and water was investigated. In this gage, the surface tension at the kerosene–alcohol interface was about one-tenth that of the kerosene–water interface in a tube of like diameter. The surface tension effect of the kerosene–water interface in reservoirs of 4-in. diameter, used in this gage, was large enough seriously to affect the accuracy of the readings.

The results of the studies on capillary rise made for both liquid–air and liquid–water interfaces of several of the liquids are shown in Table II.

CONCLUSIONS

It appears that the multiplication obtained by the use of a two-liquid gage is actually as expected, but the presence of a comparatively large force in the gage tubes at the interfaces of the liquids disturbs the readings in such a manner as to destroy the usefulness of the device. The results with a three-liquid gage are no more satisfactory, and the calculations involved are much more laborious. Hence it is concluded that the latter type of gage is also impractical.

ENGINEERS' NOTEBOOK

From everyday experience engineers gather a store of knowledge on which they depend for growth as individuals and as a profession. This department, designed to contain practical or ingenious suggestions from engineers both young and old, should prove helpful in the solution of many troublesome problems.

Seepage Through Foundations and Embankments Studied by Glass Models

By HIBBERT M. HILL, ASSOC. M. AM. SOC. C.E.
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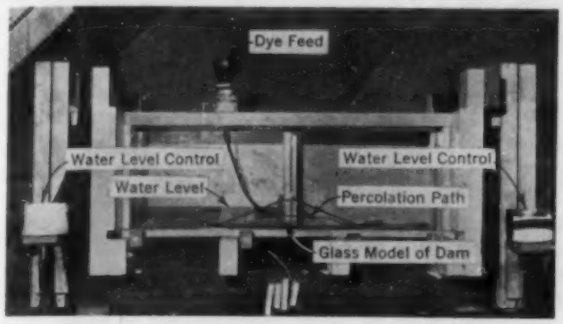
GREAT mathematical complexity characterizes the majority of problems dealing with flow through pervious materials. Moreover, many of the basic problems have refused thus far to yield to a rigid mathematical solution. I have recently found a readily applied experimental method which in many cases will provide a practical solution for complex problems of seepage flow. Certainly the method gives an excellent picture of the character of the flow in such cases, and disabuses the mind of a number of erroneous notions.

This method is based on the fact that seepage in all cases of practical importance is stream line, or laminar, and that the flow between closely spaced plates of glass has this same characteristic. This latter fact has been used by Hele-Shaw and others to demonstrate certain flow phenomena. By cutting the profile of a foundation, embankment, or other pervious structure from a plate of glass, arranging this profile in proper position a short distance (about 0.01 in.) from a second plate of glass, and allowing flow to occur between the model profile and

its adjacent plate, the conditions of flow through a homogeneous prototype of earth or sand are simulated. The relation between the permeabilities of model and prototype is of no importance. The directions and relative velocities of the flow, and the pressure distribution, will be correctly simulated as long as the prototype is homogeneous. Non-homogeneity of prototype can also be simulated, but these notes are not concerned with that condition.



MODEL-TESTING FLUME WITH GLASS MODEL OF AN EARTH FILL DAM IN PLACE
Percolation Paths Were Determined by Introducing Dye at Given Points

In the method described, a glass-sided flume 36 by 12 in. in elevation, with suitably arranged headwater and tailwater controls, is used. Proper spacers are placed against the glass of the flume, and the model is pressed against them. Dye is introduced at points along the upstream edge of the model, and the flow lines are traced with ink or glass pencil on the glass of the flume, and then later traced on coordinate paper.

Certain data are determined directly from the apparatus, as follows: (1) direction of flow, (2) the relative velocities at various points in the model, and (3) the total discharge of the model. From these data, or such of them as are desired, further computations and comparisons are possible. One important derivation is the distribution of pressures.

In Fig. 1 is shown the direct determination, from the model, of the flow lines beneath a dam with an upstream cut-off wall about as long as the foundation is wide, and in a homogeneous pervious foundation of considerable width and depth. On this diagram the flow lines appear as they were traced directly from the model, but the equipotential lines have in part been added, to show the pressure distribution. In the insert, the distribution of uplift on the base of the dam, as taken from the main diagram, is shown.

Each flow line in Fig. 1 represents a stream tube of constant discharge, though of varying velocity and cross section. The space between two adjacent flow lines therefore has a constant discharge, and in its characteristics approximates a stream tube. The closer the lines are together, the better the approximation. If the space between two flow lines is assumed to be a stream tube, after the method of Philipp Forcheimer, then the variation in width of the space is inversely proportional to the change of velocity in the space. In any stream tube,

$$v = ki \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

in which v is the velocity, k the coefficient of permeability, and i the hydraulic gradient at the point in question.

Suppose, therefore, that the space between two lines, or A — B in Fig. 1, is divided mechanically into approximately equal squares, of which there are a certain number, n. Let Δl be the length of side of any square. Then, since

$$Q = Av \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

$$v \alpha \frac{Q}{\Delta l} \alpha k \frac{\Delta h}{\Delta l} \quad \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

where Δh is the loss of head in the square, that is, in the distance Δl. Hence, from Equation 3,

$$Q \alpha k \Delta h, \text{ or } \Delta h \alpha \frac{Q}{k} \quad \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

Since $\frac{Q}{k}$ is a constant, Δh must also be a constant. Then

$$n \Delta h = h = \text{total head} \quad \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

and

$$n = \frac{h}{\Delta h} \quad \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

Therefore each square represents a loss of head of h/n units. In this manner the proportionate pressure at the downstream boundary of each square is determined. This boundary also determines a point on the equipotential line representing that particular pressure. The equipotential lines must be perpendicular to the flow lines and to the fixed boundaries, that is, to the base of the dam, to the cut-off walls, and to the boundaries of the permeable stratum. It is therefore easy, by trial and error, to sketch in the remaining parts of the equipotential lines, and from the intersection of these with the base of the dam to read the pressure distribution there, as shown in the insert

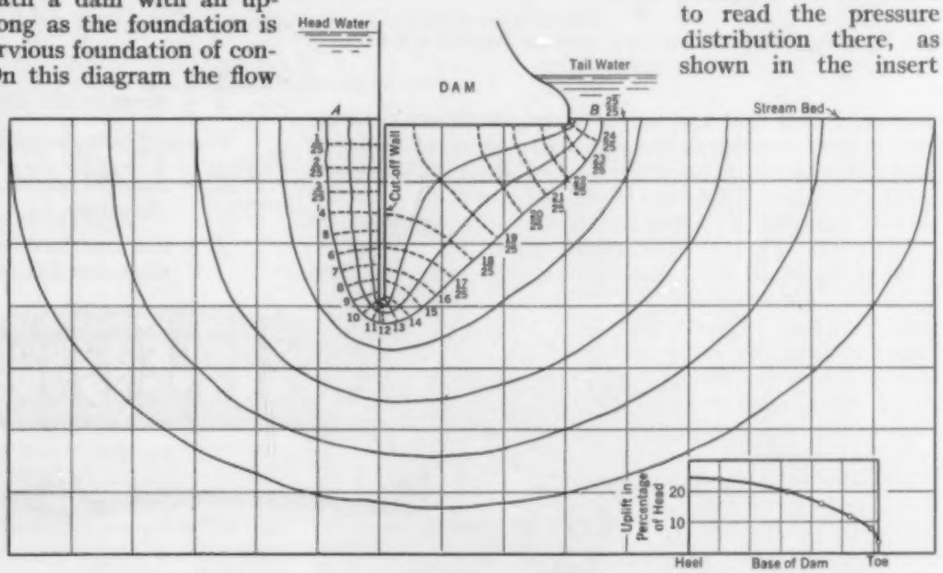


FIG. 1. FLOW LINES AND LINES OF EQUAL PRESSURE IN WATER PERCOLATING BENEATH A MODEL DAM
Graph in Insert Gives Distribution of Uplift Pressure

curve of Fig. 1. This curve shows that the usual assumption of linear pressure distribution is erroneous.

In Fig. 2 are shown the flow and equipotential lines for a particular condition in a homogeneous earth embankment on an impervious foundation. As in Fig. 1, the flow lines are taken from a glass model, whereas the equipotential lines are sketched in. It is interesting to note, in this model, that there is a considerable capillary flow above the elevation of what, in the prototype, would be the piezometric line, that is, an approximately straight line drawn from headwater level to tailwater level. A further point of great interest is the concentration of the flow lines at the exit, near the tailwater surface, indicating high exit velocities at that point and consequent danger of failure there.

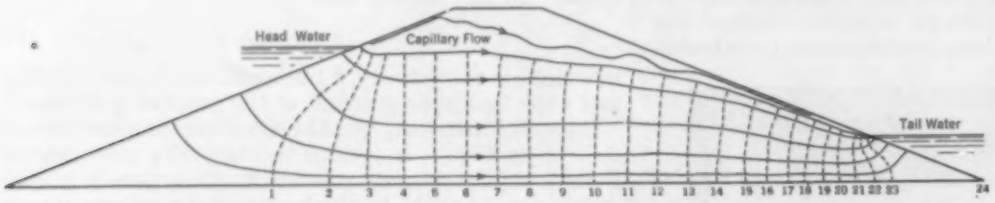


FIG. 2. PERCOLATION LINES THROUGH AN EARTH FILL DAM ON AN IMPERVIOUS FOUNDATION, AS DETERMINED BY A GLASS MODEL

The results obtained from the glass models are believed to be theoretically correct. They have been compared with experimental results obtained by me and by others from much larger models built of sand, and found to agree. In cases where the method is applicable, it has the great advantages of low cost, adaptability, and speed and ease of operation. It has the further great advantage that the whole process, in a measurable form, is presented visually, resulting in an understanding of, and confidence in, the results not obtainable by other methods. In conjunction with a general investigation of the subject of earth dams, I am now carrying on a detailed study of the glass-model method of studying seepage flow.

Determination of Stresses and Displacements for Z-Trusses

By PAUL ANDERSEN, ASSOC. M. AM. SOC. C.E.

URBANA, ILL.

AFTER some recent investigations of the economic arrangement of web members in long-span steel trusses, I find that the use of short compression members makes possible a considerable saving of material and effort in the fabrication and erection of long-span steel structures. The mathematical problems involved in the analysis of the Z-frame may be explained by reference to a typical truss, shown in Fig. 1.

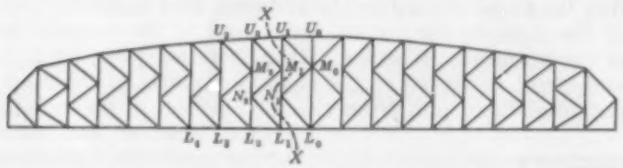


FIG. 1. STRESSES IN MEMBERS FOUND BY PASSING A Z-SECTION THROUGH A PANEL

This figure shows a method of passing a Z-shaped section, XX, through each panel to determine the stresses in the members. The web arrangement, which is an evolution of the K-principle, can be applied advantageously to long-span steel trusses with panel lengths shortened to about one-third the truss depth. The Z-truss is statically determinate. This can be ascertained by applying to a system of Z-panels the relation,

$$m = 2j - 3 \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

in which m is the number of members and j, the number of joints.

To determine the stresses in the top and bottom chords, cut a section, XX, as shown in Fig. 1. Since all the web members cut by this section go through both U_3 and L_3, the chord stresses can be found by taking moments about these points. The horizontal components of the three diagonals in a panel are numerically equal. If, therefore, the diagonal stresses in panel L_3L_4 are resolved into their horizontal and vertical components, and the moments about the intersection of the two chord members are balanced, the stress becomes

$$S = \frac{M}{3\,L \sin v} \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

in which

S = stress in the diagonal

v = angle between the diagonal and the horizontal

M = moment about the intersection of the chord members

L = distance between L_3 and the intersection of the chord members

APPLICATION OF Z-TRUSS PRINCIPLE TO A SIMPLE SPAN

A similar equation can be obtained for stresses in the vertical web members.

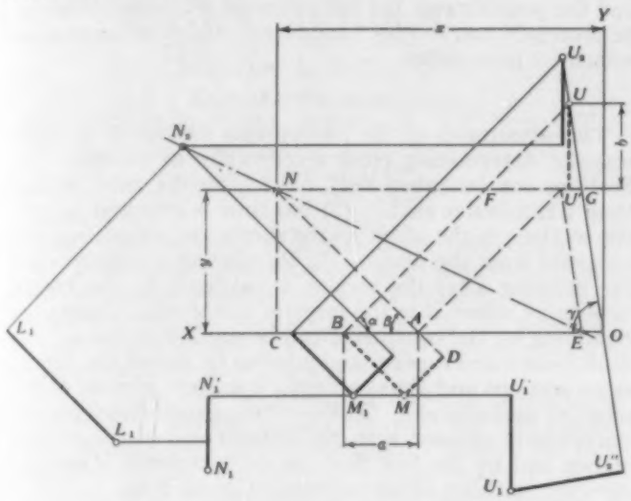


FIG. 2. WILLIOT DIAGRAM FOR A Z-TRUSS

How a Williot diagram can be drawn for a Z-truss is shown in Fig. 2. If the member L_0U_0 is taken as the reference member, points in the diagram corresponding to M_0, L_1, N_1, and U_1 are readily located. An attempt to locate M_1 by the usual method of plotting the deformations, N_1N_1' and U_1U_1', from N_1 and U_1, respectively, and erecting two perpendiculars, will show that they coincide. Hence, M must lie somewhere on the line $N_1'U_1'$. It is also known that N_2 must be on a line normal to the member L_1N_2 (in the truss), at a distance from L_1 (in the diagram) equal to the deformation of the member L_1N_2. Likewise, U_2 must lie on a line through U_2'' normal to the member U_1U_2.

In order to find out whether a casual point, M, on the line $N_1'U_1'$, is the point in the diagram corresponding to the joint M_1 in the truss, draw the polygon $DMBUU'N$, with MB, MD, and UU' equal to the known deformations of the members M_1U_2, M_1N_2, and U_2N_2, respectively. As is made clear in Fig. 2, the intersection N does not fall on the line perpendicular to L_1L_1'. Hence N is not the point sought.

Suppose the point M is moved along the line $N_1'U_1'$ and a search is made for the locus of point N. Using the coordinate system and the notation indicated in Fig. 2, it is found that

$$x = OC = OB + BA + AC$$
$$OB = (b + y)(\text{ctn } \alpha + \text{ctn } \gamma);$$
$$BA = -a; \text{ and } AC = y \text{ ctn } \beta. \text{ Hence}$$
$$x = y(\text{ctn } \alpha + \text{ctn } \beta + \text{ctn } \gamma) + b(\text{ctn } \alpha + \text{ctn } \gamma) - a \quad [3]$$

This equation shows that the locus for points N is a straight line. By substituting zero for y, the location of the intersection of this line and the X axis is found.

$$OE = b(\text{ctn } \alpha + \text{ctn } \gamma) - a = FG - AB \quad [4]$$

The construction of point N_2 in the diagram is therefore as follows. Select any point, M, on the line $N_1'U_1'$ and proceed to find N, using the known deformations and directions of members. Locate E by the method previously explained. Find the point N_2, the intersection of NE and a line perpendicular to L_1N_2 (in the truss) at a distance from L_1 (in the diagram) equal to the elongation of the member L_1N_2. Draw the polygon $M_1U_2N_2$.

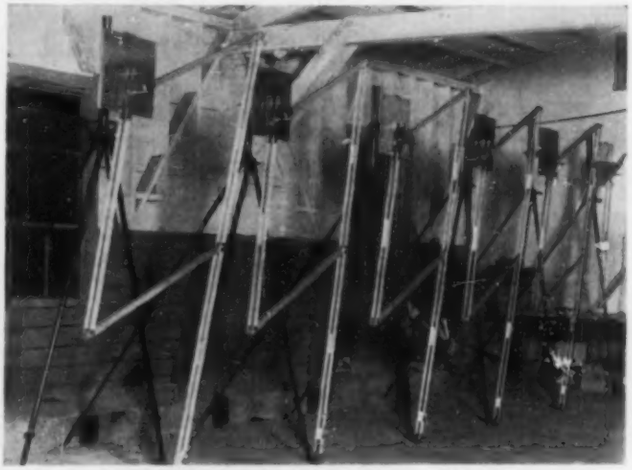
FIG. 3. Z-TRUSS PRINCIPLE APPLIED TO A CANTILEVER BRIDGE

Pantograph Device for Tunnel Cross Sections

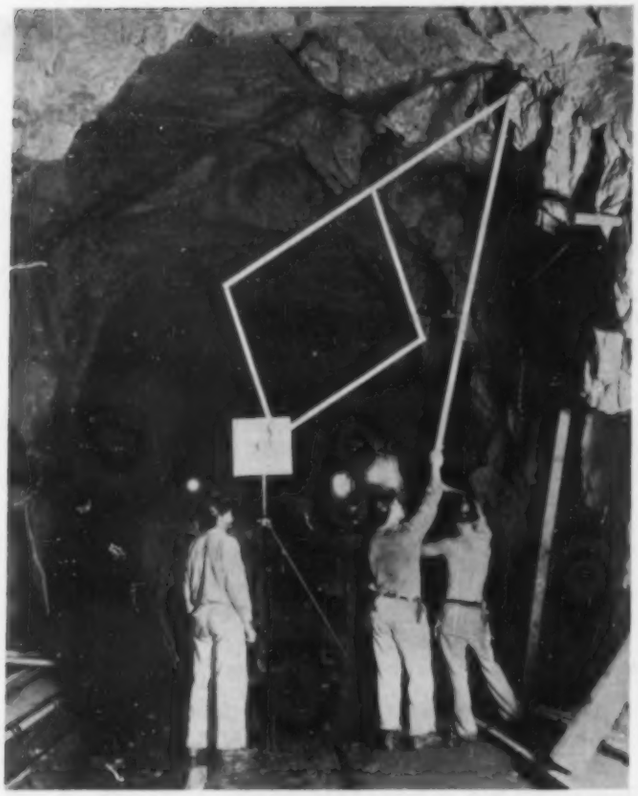
By BEN A. EDDY, M. AM. SOC. C.E.

RESIDENT ENGINEER, DIVISION NO. 5, METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA, BANNING, CALIF.

EARLY in 1933, the Metropolitan Water District of Southern California purchased a number of Proebstel pantograph instruments, for use in making cross sections of the tunnels being constructed on the Colorado River Aqueduct. The instrument consists of a spruce pantograph frame with a rubber-covered roller at the end of the tracer arm, and a pencil point set for a reduction in scale of 1 to 24. The pantograph is suspended from a hub located at the center of a 16 by 16-in. aluminum plate which serves as a holder for the 12 by 14-



TUNNEL PANTOGRAPHS USED ON THE COLORADO RIVER AQUEDUCT



TAKING CROSS SECTIONS OF A TUNNEL BY MEANS OF THE PANTOGRAPH

in. cross-section sheets. An adjustable clamp holds the aluminum plate to a vertical standard mounted on a tripod, which has adjustable legs made of steel pipe. By moving the plate up or down on the standard, the horizontal axial line of the chart is adjusted to a fixed elevation above the tunnel invert.

When it is desired to transfer the instrument from one station to another, the pantograph frame may be removed from the aluminum plate by taking off a nut on the end of the hub. Variations in radius of operation of from 5 ft 3 in. to 12 ft 9 in. can be recorded with this instrument.

OPERATION OF THE INSTRUMENT IN A TUNNEL

In taking a cross section of a tunnel, the instrument is set up on the center line of the tunnel over a point whose elevation has been previously determined. The aluminum plate is then leveled by means of a spirit-level mounted on its top, and the plate is set to the proper height above the reference point on the tunnel center line. A weight is hung on the forward leg of the tripod to balance the weight of the pantograph frame. A cross-section sheet with printed axial lines is placed on the plate and lined with scale points marked on the plate. The pencil point is released and the tracer-arm roller moved around the line of excavation of the tunnel. Each sheet is marked with the date, the number of the tunnel station, and the elevation of the point over which the instrument is set.

By means of a celluloid templet it is possible to show in the field the exact amount of overbreak or underbreak, and the points inside the line of minimum excavation can be promptly marked for trimming. Actual areas are obtained by planimeter.

PRACTICAL ADVANTAGES

The advantages of the pantograph method over other ways of determining cross sections are as follows: (1) Sections can be taken very quickly in the field, in less than ten minutes each. (2) No time is required to plot the sections in the office, as the sheets are complete when removed from the plate. (3) By placing a templet over the drawing after the section is taken, it is possible to determine where it is too large or too small. Points for trimming by the contractor can be marked at once. (4) Shift bosses and superintendents can be shown the tunnel cross sections and thus can get a complete picture of the over- or underbreak. (5) Operating superintendents are particularly pleased with the definiteness of the picture shown and by the fact that the desired result is secured directly, without office calculation or plotting.

In one of the accompanying photographs the method of operating the pantograph in a tunnel is shown. A sample chart is given in Fig. 1, on which appears the line of excavation as drawn by the pantograph, and the "A" line as drawn with a templet. The "A" line may be defined as the line within which no unexcavated material can be allowed to remain.

The tunnels on the Colorado River Aqueduct are constructed for a capacity of 1,600 cu. ft. per sec. and normally are 16 by 16 ft. A total of 92 miles of tunnel is to be constructed. The longest single tunnel is 13 miles between portals.

Construction of the Colorado River Aqueduct is being directed by F. E. Weymouth, M. Am. Soc. C.E., General Manager and Chief Engineer.

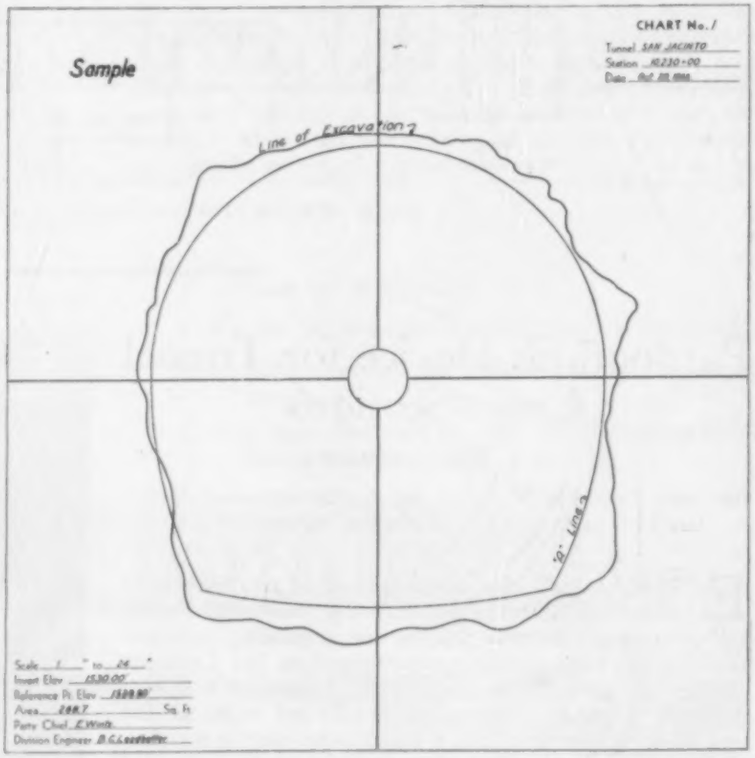


FIG. 1. SAMPLE PANTOGRAPH CHART SHOWING ACTUAL EXCAVATED SECTION
Templet Used to Draw the "A" Line, Within Which No Unexcavated Material Is Permitted to Remain. Original Chart Is 12 by 14 In.

Plotting Curves of Long Radius Without a Beam Compass

By WILLIAM N. HALL, ASSOC. M. AM. SOC. C.E.
U.S. ENGINEER REPRODUCTION PLANT, WAR DEPARTMENT, WASHINGTON, D.C.

IN the drafting room it is sometimes necessary to lay out on paper a regular curve of long radius when there is not at hand a beam compass or a drafting table large enough for the use of that instrument. A method I have employed several times with satisfactory results is best explained by an example.

In Fig. 1 the two tangents, IM and IN, intersecting at the point I, are given, together with the two points, A and B, which are equidistant from I and on the tangents IM and IN, respectively. It is required that a regular curve be drawn with A as its beginning and B as its end. First draw the long chord AB. On a sheet of tracing cloth or other transparent material trace the angle BAM. Shift the position of this traced angle, moving the point A towards B, at the same time keeping the lines AM and AB so that they pass through the points A and B, respectively. With a needle or other sharp pointed instrument, prick through the point A of the tracing at successive positions and designate these positions on the original drawing as A', A'', and A''' .... The position of the traced angle for any particular point, such as A'', will be $B''A''M''$.

Draw a curve through the points thus marked, using a railroad curve, an irregular curve or, if the curve is very flat or the points close together, a straight-edge. A smooth curve can be drawn with the latter by slightly varying the tilt of the pencil or pen.

This method is of special value where railroad curves of correct curvature are at hand but are not long enough to reach from the point of curve to the point of tangency. One or more intermediate points may be located on the desired curve and the railroad curve used to lay out the intervening sections.

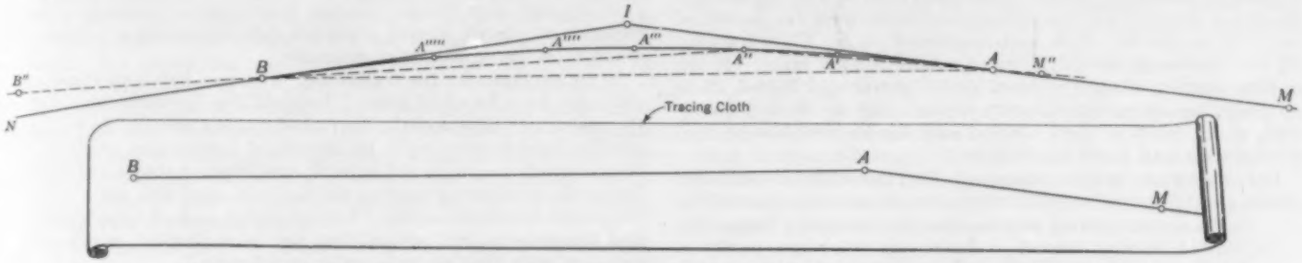


FIG. 1. METHOD OF DRAWING CURVES OF LONG RADIUS BY MEANS OF TRACING CLOTH OVERLAY

Passing a Curve Through a Fixed Point

By L. S. MACDOWELL, ASSOC. M. AM. SOC. C.E.
NANKIN, OHIO

IN an attempt to derive a simple formula to give a direct solution for the radius of a curve that will connect two given tangents and pass through a given point, I investigated four different methods but was greatly surprised at the array of trigonometric functions involved. The method here given is easily applied. The tangent of $\frac{1}{2}\Delta$ is the only trigonometric ratio required.

$$R^2 = \left(R \tan \frac{\Delta}{2} - D\right)^2 + \left(R - L\right)^2 \quad [1]$$

in which L and D are the latitude and departure of the given point (Q in Fig. 1), referred to the point of intersection of the tangents. By expanding and solving the resulting binomial,

$$R = \frac{\sqrt{\left(D + \frac{L}{\tan \frac{\Delta}{2}}\right)^2 - \left(D^2 + L^2\right)} + \left(D + \frac{L}{\tan \frac{\Delta}{2}}\right)}{\tan \frac{\Delta}{2}} \quad [2]$$

When $\Delta = 90$ deg, $\tan \frac{\Delta}{2} = 1$. The formula then reduces to:

$$R = \sqrt{2DL} + D + L \quad [3]$$

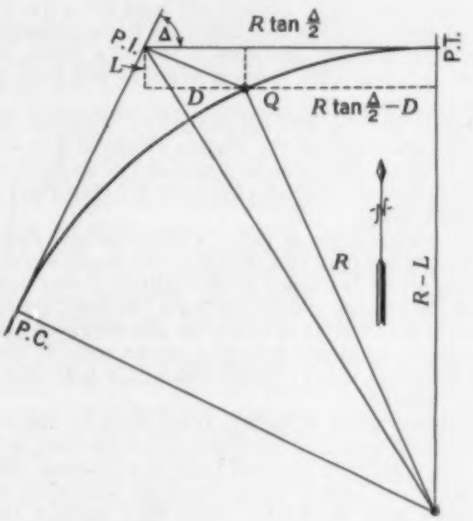


FIG. 1. TWO TANGENTS CONNECTED WITH A CURVE PASSING THROUGH A GIVEN POINT

OUR READERS SAY—

In Comment on Papers, Society Affairs, and Related Professional Interests

Cleveland's Blighted Industrial Districts

TO THE EDITOR: In connection with Mr. Millar's article on slum clearance, in the September issue, I should like to comment briefly on the situation in Cleveland, which is essentially an industrial city, dependent for its prosperity on factories and mills. Its location on Lake Erie, easily accessible to the coal areas to the south and the iron-ore areas to the north, has made it an important steel manufacturing center, and its interest in steel extends from the raw materials to thousands of finished products. For diversified manufacturing interests, Cleveland is preeminent among American cities.

The principal industrial districts may be divided into six general sections, as follows: (1) the Cuyahoga Valley and its tributaries, the oldest district; (2) the eastern lake front, from the mouth of the river to Gordon Park and southward to St. Clair Avenue; (3) the Newburgh district, devoted mostly to steel mills; (4) the eastern district, along the New York Central and Nickel Plate railroads, largely outside the city proper; (5) the West Side district, along the New York Central and Big Four railroads; and (6) the Cleveland Short Line district.

For many years there has been a decided movement of industrial plants away from the older districts, located near the heart of the city, to the newer outlying districts and the suburbs. These centrally located districts started to deteriorate years ago, partly as a result of the decrease in water-borne traffic and of changes in transportation methods. However, many large and prosperous industries, which were not in reality affected by such changes, have now left the areas for more attractive locations.

The result is the existence today of blighted industrial areas presenting civic planning problems quite similar to those of the blighted residence areas created by the outward movement of homes.

Why have these industries moved away or gone out of business? Some of the reasons advanced are as follows: (1) high taxes; (2) need for more room for expansion, since modern manufacturing methods favor the one-story, or low building, as compared to the multi-story type, and such buildings require much greater land areas; and (3) desire for better surroundings. Factories in the outlying districts are more modern and more attractive architecturally, and naturally draw new industries to their neighborhood. The situation is precisely analogous to that of a citizen buying a new house; he prefers the location where he will have the best neighbors.

What should be done with the abandoned industrial districts? It has been suggested that the existing industrial area along the lake front in Cleveland should be abandoned as such and re-zoned for apartment houses. The plan has much in its favor and is worth serious consideration.

As to the lower Cuyahoga Valley, a comprehensive plan for the improvement of the river to a certain extent would attract industries desiring wharf facilities. If, in addition, it were possible to clear away the obsolete and tumble-down buildings, extend or relocate some of the streets, and supply the area with good usable raw water, an almost ideal new industrial section could be created in the lower Cuyahoga Valley. Land values there have already been completely deflated.

For the improvement of the lake front, along the old industrial section extending from East 9th Street to Gordon Park, a distance of about 3½ miles, it is proposed to build a marginal trafficway and railroad about 1,300 ft inside the harbor line, which coincides approximately with the present shore line. Such a trafficway would fill three distinct civic needs: a high-speed avenue serving the northeastern residence and new industrial areas; a means of reaching more easily the older industrial district now blighted, lying immediately to the south of the proposed trafficway; and the development of the water front itself, partly for commerce, partly for pleasure, and partly for new industries.

WILBUR WATSON, M. Am. Soc. C.E.
Wilbur Watson and Associates
Architects and Engineers

Cleveland, Ohio
November 29, 1933

Survey Monuments Difficult to Preserve

DEAR SIR: The article by Mr. Whitmore on "City Surveys—Past, Present and Future," in the August issue, presents many thoughts of interest to civil engineers and land surveyors, some of which show his constructive optimism.

In connection with his statement, "The cart has been ahead of the horse for a hundred years," I should like to comment. This statement may be true of the 13 original states where the old boundary-line surveys were made by metes and bounds and are largely disconnected, but it is not true of our Western states and cities unless the subdividers ignored the national land-title plan. Mr. Whitmore is right in saying, "For simplicity, ease of computation, and permanence, no method has yet been devised which can compare with that of rectangular coordinates."

A comprehensive system of rectangular coordinates has been used for the sectional surveys of Western cities. The history of surveying shows that the rectangular plan employed in these cities is the only system which accommodates the changes necessary to expansion. Mr. Whitmore wisely suggests connecting surveys with the "triangulation of the U. S. Government." Tying any monument to "the national triangulation net" will certainly help preserve its location, but with the statement that it will thus be preserved "for eternity" I cannot agree.

Since the time when man first used boundary lines, he has established monuments which were to last forever, but did not. In 1819, just 114 years before Mr. Whitmore's paper was read in Chicago, J. Meigs, of the General Land Office, wrote concerning the virtues of the sectional survey system as follows:

"This wise system takes away all temptation to incur the curse pronounced by Moses on him 'who removeth his neighbor's landmark.' The landmark is indeed immovable for, though the marked trees at any one corner may be . . . destroyed, yet . . . half a mile east, west, north, or south there are other trees by which the true corner may be found."

This faith was not well founded, not because the rectangular survey system was faulty, but because the half-miles were not correctly measured. One reason for this inaccuracy was the fact that people would not wait for accurate surveys. In fact, at one time the Army had to go into Ohio to drive out unauthorized settlers.

Half-mile units can now be accurately measured if the location of the old monuments can be found. To obtain evidence of such locations, measurements must be made along the quarter-section lines. Mr. Whitmore rightly says, "The main requirement is that all street corners . . . be connected . . . to the . . . triangulation." In our Western cities there are few monuments at street corners that need not be checked. All evidence of location of these corners cannot be found without measurements and ties along street lines.

The degree of accuracy of any survey made for posterity is of value only in so far as it preserves the location of monuments. What is a permanent monument? In Chicago the most lasting monuments are steel-frame buildings with caissons extending to rock. If new caissons are constructed alongside, we watch even

these structures for settlement and we often find that old buildings on floating foundations have moved both vertically and horizontally. What assurance is there that any monument set 5 or 10 ft into the ground will maintain its exact position for one hundred years? The eternal question to be asked in connection with any boundary-line survey is, where was that monument when it created the corner?

So far, land surveyors have not been much concerned with vertical locations as boundaries. However, within the next hundred years they will be, because long before that time the legal question will be, just where was that datum when those air rights were deeded?

W. D. JONES
Land Surveyor and Civil Engineer

Chicago Ill.
November 27, 1933

First Suspension Bridge Built in America

DEAR SIR: The foreword to the symposium on the "Design of Modern Suspension Bridges," in the September number, contains three historical errors. The originator of the modern suspension bridge spelled his cognomen Finley, not Finlay; at least he did in 1810. His praenomen was certainly James, not Charles, and he built his first bridge in 1801, not 1796. For proof see his article in the *Port Folio* (an American literary journal), June 1810, pages 441–453. His illustration for this article shows a continuous wooden floor truss about 6 ft deep for a bridge of 200-ft span. In his discussion, however, Finley devotes almost no attention to the truss, except to observe that the top chord will be twice as strong if built as a continuous beam.

A few quotations from Finley's long article may be of interest.

"There is no reasonable doubt that in some extraordinary case this kind of bridge will be extended to one thousand feet, when the subject shall be fully understood; and should it ever be necessary. I would undertake to satisfy any person concerned, that it is capable of a still greater expansion."
"But supposing the chain bridge should become a total wreck in five hundred years . . . ."
"May I not with some degree of exultation ask, who ever thought of the skeleton of a bridge so light and so strong, so permanent, and so easily erected and repaired or renewed in such parts as may require it?"

Finley explains, in considerable detail, how he made his drawings on board fences or partitions and used "pulley-whirls" and weights in his experiments with models. To show that he is not at all apologetic concerning his methods of stress analysis, I quote the following:

"I know the young mathematician, with mind half matured, would smile at my mode of testing the relative force and effect of the several ties and braces of any piece of framing; but the well informed will not so lightly treat any information obtained or supposed to be obtained by actual experiment."

R. S. KIRBY, M. Am. Soc. C.E.
Associate Professor, School of Engineering, Yale University

New Haven, Conn.
November 7, 1933

* * * * *

TO THE EDITOR: In Professor Kirby's interesting discussion of the foreword of my article, in the September issue, he says that James Finley built the first suspension bridge in 1801. The source of his information, an article written by James Finley himself, is of course irrefutable.

It may be of interest to quote briefly from this article: "In the year 1801, I erected the first bridge on this construction over Jacob's Creek, on a contract with Fayette and Westmoreland counties, to build a bridge of 70-foot span, twelve and a half feet wide, and warrant it for fifty years (all but the flooring) for the consideration of six hundred dollars."

However, a study of the literature on early bridges reveals some interesting inconsistencies. For example, all the following references give 1796 as the date of construction of the first suspension bridge in the United States.

1. *Rapport à Monsieur Becquey et Memoire sur les Ponts Suspendus*, Navier, Paris, 1830.
2. *A Memoir on Suspension Bridges*, Charles Stewart Drewry, London, 1832, page 11.
3. Paper by Charles Bender read before the Society, March 18, 1868, and published in TRANSACTIONS, Vol. 1, page 28.
4. *Engineering-News*, Vol. 53, March 16, 1905, page 269.
5. *The Cornell Civil Engineer*, Vol. 19, April 1911.
6. *Ponts Suspendus*, G. Leinekugel le Cocq, Vol. 1, page 4, Paris, 1911.
7. *Bridge Engineering*, J. A. L. Waddell, Vol. 1, page 21, New York, 1916.
8. *A Practical Treatise on Suspension Bridges*, D. B. Steinman, Chronological Table, New York, 1929.

All these references, except the second and eighth, give the builder as James Finley. The second calls him "Mr. Finlay" without any praenomen, and the eighth mentions no name at all and gives the span as 72 ft instead of 70 ft. None of these references gives the source of its material.

The only references that contain the same information as the *Port Folio* are *A Treatise on Bridge Architecture* (Thomas Pope, New York, 1811), and the *American Civil Engineers' Handbook*, Fifth Edition, page 1,276, New York, 1930.

In *Bridge Engineering*, H. G. Tyrrell, (page 204, Chicago, 1911) gives 1801 as the date, but says that Finley made small-scale experiments three or four years before.

Still another reference, *Histoire de la Navigation Interieure* (J. Cordier, Vol. 2, Paris, 1820), gives the name as S. Finley.

The majority of authorities give 1796 as the date, although they all neglect to mention the sources of their information.

A. A. JAKKULA, Jun. Am. Soc. C.E.
Assistant Professor in Civil Engineering
University of Michigan

Ann Arbor, Mich.
November 29, 1933

Undesirable Features of the Highway By-Pass

TO THE EDITOR: Kindly permit me to make a few comments on the letter by A. W. Robertson, in the December issue, which outlines the development of a two-lane highway, with by-passes on each side for the purpose of permitting commercial vehicular traffic to follow the line of deflection while fast passenger traffic proceeds in the normal lane. It should be realized that this is by no means a new suggestion.

About fifteen years ago a proposal for such a by-pass was first made for highways carrying heavy commercial traffic, through sections where steep grades were encountered. It was thought that slow-moving, heavily loaded trucks ascending a grade could drop out of the stream of traffic and permit fast passenger cars to proceed up the grade without having to pass these heavy, slow-moving vehicles in the same lane occupied by the fast traffic descending. However, this proposal was never put into effect and, so far as I have been able to determine, no one has ever had the temerity to suggest carrying out such a plan on highways with normal grades.

On a crowded two-lane highway the menace of permitting heavy, slow-moving vehicles to leave the stream of traffic and to enter it at an acute angle, or any other angle, is obvious. In our highway designs, we introduce traffic into a stream at right angles. Thus the operator of the vehicle has an opportunity to observe the traffic in both directions and to regulate his vehicle so that he can make a safe entrance into the stream. It would be advantageous for those immediately to the rear of a slow-moving vehicle to have it swept into the by-pass, but there would be a tremendous disadvantage in this procedure to all traffic as soon as the vehicle attempted to reenter the stream.

It is gratifying to observe that the undesirability of "saturated" two-lane highways is being recognized, but it must be impressed upon the public that no such cure-all as is outlined in Mr. Robertson's communication is practical. Delay in the movement of traffic, distortion of the traffic stream, and increase in the number of accidents would result if such a proposal were carried out. Although I do not, in general, advocate a three-lane highway, it does eliminate all the difficulties that are present in a two-lane highway and gives an economical solution to the problem of a crowded two-lane highway. However, it must be considered as a transition step toward a four-lane highway.

The detrimental effect of interspersing heavy commercial vehicles in the stream of traffic is generally realized. However, highways have a commercial value, and if they are to be utilized to the fullest extent they must encourage commercial traffic. With recent mechanical improvements in the braking power and increased speed of vehicles, truck traffic no longer causes the delays for which it was responsible a few years ago, and the situation will probably be even better in the future. The overloading of a truck through the desire of the owner or operator to carry a maximum pay load often leads to accidents, as such a vehicle cannot maintain a proper speed and is also apt to get out of control when descending a grade. This condition can be corrected by permitting the discretionary powers of the proper authorities to function, so that the vehicle will not be burdened with a load that it was never designed to carry.

Railroad operation has been cited as an example of the movement of slow and fast traffic over the same artery. It is true that a freight train can be switched to a siding to permit a fast train to pass it, but it is equally true that the signaling system which is incorporated in the operation of a railroad, together with the fact that the equipment is confined to rails, creates conditions dissimilar to those of highway operation. The traffic situation is so serious that our associates engaged in park developments prohibit the entrance of vehicles into the traffic stream except at well-defined places, under carefully designed systems of entrance.

E. W. WENDELL, M. Am. Soc. C.E.
Principal Grade Separation Engineer
New York State Department of
Public Works

Albany, N.Y.
December 6, 1933

"Comparable Bituminous Types"—A Fallacy

TO THE EDITOR: Years of observation both as an engineer of a state highway department and as an official in a highway materials company have confirmed my conviction that the expression, "comparable bituminous types," has been grossly abused. It is common knowledge among engineers, and in fact among highway and street officials too, that there are no comparable types in the generally accepted meaning of the expression. Each kind, if properly designed, will cost a certain amount to build. The maintenance expense will be different for each type. The actual life of each will vary. Each possesses features not inherent in the others.

Yet engineers and officials regularly include under this misleading term, at the insistence of manufacturers' representatives, materials which they know cannot be used on a particular job, even though lowest in price. Thus, the practice promotes lost motion and wasted effort and, at times, embarrassment for all concerned.

The situation is further complicated by insistence that, since the competing materials are all classified as "comparable bituminous types," they should be specified to have the same thickness. This is sometimes done in spite of the fact that engineers know from experience that such practice is ill advised.

Why not stop using high-sounding, meaningless phrases in an attempt to delude the public or to appease the insistent demands of salesmen and promoters that their particular types of road materials should be included in every letting and specified no thicker than competing materials? This practice violates every fundamental of sound engineering. First of all, let us deal honestly with the job to be done by selecting the particular material that best suits conditions and pocketbooks. There will then be effective competition, not only among contractors, but also among manufacturers furnishing materials that may be used in construction. Other conditions prevailing, another type may be selected for the next job.

Specify the proper thickness of wearing course for each type, regardless of the thickness needed for another type. In other words, the engineer should know materials and use the proper one to get economical, lasting results. Following this plan, all reputable materials will find a place in the road-building program of the country, and all reputable producers of road materials will be able to get some business.

There is not and cannot be any fair competition as between types, and the sooner this is recognized and the present practice abolished, the easier will it be for good business concerns to secure legitimate business; the sooner will contractors save money that they are now wasting in traveling around the country bidding on types that will never be built; and the sooner will officials be relieved of embarrassment in doing their duty by awarding contracts to other than the low bidder, which always exposes them to public criticism.

RODMAN WILEY
Sales Manager, Kentucky
Rock Asphalt Company

Louisville, Ky.
November 25, 1933

Depreciation Estimate Questioned

TO THE EDITOR: In Mr. O'Brien's article, "Evaluating Steel Storage Tanks," in the October issue, he states, "This method of computing depreciation gives a faster depreciation for the earlier

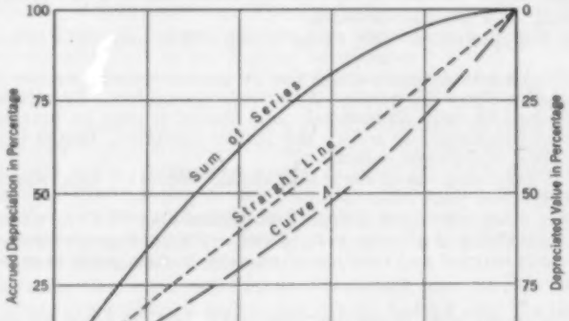


FIG. 1. COMPARISON OF CURVES OF ACCRUED DEPRECIATION

years which, it is believed, is nearer to true conditions than the assumption of equal depreciation annually."

The method of estimating depreciation outlined in this article, and called the "sum of series" theory, will give results that are decidedly misleading and are not borne out by experience with water works or other plant. Experience has shown that depreciation, or loss in value, usually is gradual and slight during the early years of the life of the plant and increases with the lapse of time. There seems to be no logical basis for assuming that steel tanks depreciate in the opposite way. It is unlikely that anyone could show a material loss in the value of a tank one year old.

It is often thought that an exception to this general rule is the case of depreciation in an automobile, which is worth about one-third less than its purchase price immediately after purchase. This, however, is neither depreciation from natural wear and tear nor functional depreciation. It might be considered a case of "obsolescent depreciation" as it results from the fact that the automobile has become a last year's model or a "used car."

In the past it was common practice to compute depreciation by means of sinking fund tables, using estimates of life and the actual age

of the plant. Doubtless the "sinking fund method" of computing depreciation was originally based more on the idea of amortization of investment than on that of loss of value. It is obvious that a sinking fund, as such, can bear no necessary relation to depreciation. It does, however, offer a convenient method of obtaining a smooth curve, which in general fulfills the conception of depreciation and gives a ready means of obtaining annual depreciation percentages. A parabolic curve with vertical axis might equally well be used. In any event such curves should be used only as a guide to judgment in cases in which there is considerable difficulty in making an adequate inspection of the condition of the plant, so as to estimate reasonably its value on the basis of its condition.

It is believed that a curve, such as Curve *A* in the accompanying Fig. 1, will more nearly portray the actual accrued depreciation, or the depreciated reproduction cost of such a plant than will the depreciation found by the "straight line" or the "sum of series" method, also plotted in the figure. A life of 25 years has been assumed for purposes of comparison only, since in all likelihood the life of steel tanks properly maintained will materially exceed this period.

SCOTT KEITH, M. Am. Soc. C.E.
Assistant Engineer, Metcalf and Eddy

Boston, Mass.
November 24, 1933

Advance Planning to Combat Depressions

TO THE EDITOR: There is little in Colonel Sawyer's article, in the September issue, to which exception can be taken. Although we may vary in degree of optimism as to future opportunities, we are united in the conviction that government must henceforth proceed on a more logical basis and that one of the most essential requirements in governmental procedure is the careful analysis and programming of public works. The more stringent public finances become, and the more pressing the social problems that arise, the greater is the need for planned procedure.

Undoubtedly the present financial plight of many municipalities is due to, or has been much aggravated by, hit-or-miss expenditures for public improvements. The fault of city administrators has been less that of spending too much than of spending unwisely of time and of spending in the wrong places.

Broad physical planning and long-term programming and budgeting of public works and expenditures are essential to the efficient and economical growth and development of cities, regions, and states. However, there must be a change of policy as to when to incur public debt for such purposes. During periods of prosperity more public works should be paid for out of current revenue, under a pay-as-you-go policy. Taxes can then be raised in proportion to the increased ability of the taxpayer to pay them. The time to use public credit is during periods of depression when taxes become burdensome and when extensive public works may be initiated to take up the slack of unemployment in industry.

Relieved of their accustomed cost burden of current improvements, taxes can be reduced, after allowance has been made for the newly incurred debt charges. With the return of normal economic conditions, capital improvement programs may be reduced by the amount of work that has been accomplished during the emergency. By building up reserves in times of prosperity for use during depressions both in meeting debt charges and in financing relief projects, taxes could be still further reduced during periods of depression.

In emphasizing the importance of the city plan in programming and budgeting capital improvements, Colonel Sawyer has neglected to mention an equally valuable function of the plan, that of guidance of normal and routine development without the stimulation of new projects. In the exercise of this function of the city plan, time has no significance.

To outsiders it may seem that the authority and functions of the Federal Employment Stabilization Board are lacking in coordination and are greatly weakened by the absence of anything resembling a national plan. In some department of the National Government there should be set up a planning agency with the power and duty of making and protecting a development plan for the country on a national scale. This could be done either by extending the authority of the present board or by creating a new bureau.

The cost of being without a national plan will almost certainly be demonstrated in the present national emergency; first, perhaps, by a measure of delay in getting work under way, and much more seriously, by the construction of projects of questionable relative merit. The same thing will be true in most cities, counties, and states, and the cost will be greater in inverse proportion to the size and complexity of the governmental unit concerned. It may be said that the primary purpose of the huge public works program that the Nation and its subdivisions are about to undertake is to stimulate the flow of currency, and that it is justified for that purpose alone. But when the real needs of the country are visualized and when it is realized that the flow of public money must almost certainly stop before all, or even a large part, of these needs are met, it seems almost tragic that the present moment should find city, state, and Nation so ill prepared.

RUSSELL VAN NEST BLACK, M. Am. Soc. C.E.
City Planner

New Hope, Pa.
November 21, 1933

Present Need for Trained Surveyors

DEAR SIR: The articles by Messrs. Greeley and Jones, in the September issue, touch on a branch of engineering that too often is not accorded proper recognition. In so far as the work of the engineering profession affects the comfort and convenience of the public, it is of increasing interest to the layman. Of recent years there has been a growing tendency to bestow upon the engineer some of the rewards justly due him for his accomplishments. The work of the surveyor, however, usually carries with it little appeal to the popular imagination, and the engineer in this field often finds himself relegated to the status of an artisan, notwithstanding his specialized knowledge and experience.

It is unfortunate that such should be the case. The qualified surveyor must bring training and skill of the highest order to the practice of his profession, and these, together with the importance of his work, well entitle him to recognition and remuneration comparable to those of his predecessor, the *agrimensor* of Rome.

To my mind, a knowledge of the methods and diosyncrasies of the older surveyors is of extreme importance to the surveyor of today. His task is to retrace former lines, following if possible in the footsteps of the original surveyor and replacing his corners in their original position. (The number of people who should know this, but do not, is amazing.) If, for example, the surveyor knows than an original line was run by a person who always measured down a slope with the forward end of the chain held some 5 ft in the air, he may proceed with his retracement with the reasonable expectation of finding evidence of the original corner when he has measured off the proper distance.

The specific cases cited in Mr. Jones's paper require no comment. The surveyor, however, does not always find his original deed description closing, or such evidence of the position of the original line as is shown in Fig. 3 of Mr. Jones's article. It is in situations like these that he is compelled to usurp the functions of the courts and constitute himself counsel, judge, and jury, in order to please his client and satisfy his conscience. He is sometimes fortunate enough to do both.

These two papers should be read by the layman and his attorney, two individuals who usually hold the purse strings and are frequently antagonistic to the surveyor, with profit to them both. A more general understanding of the foundation upon which the surveyor's work is built and of the obstacles that he is required to overcome should help in some measure to smooth his path in the field and make pleasant his work on the witness stand. The chapter on "The Surveyors," in *The Cabin*, by Stewart Edward White, might also be recommended.

MORGAN M. LEWIS, Assoc. M. Am Soc. C.E.
Civil Engineer and Surveyor

San Rafael, Calif.
November 10, 1933

Comments on Velocities in an Open Channel

TO THE EDITOR: Two brief comments may be made on Mr. Stevens's article, "The Hydraulic Jump in Standard Conduits," in the October number.

The first concerns the fact that velocities in an open channel are rarely uniform over a cross section. Although very little about the subject is known at present, this fact should be kept in mind in all cases where uniform velocities are customarily assumed. The practical effect is to introduce a coefficient, slightly greater than unity, representing the ratio of the mean squares or cubes of point velocities to the square or cube, respectively, of the mean velocity in the section considered.

In the present case, the change of momentum per second is $(w/g)\ (\int v_2 dq_2 - \int v_1\ dq_1)$, where w is the specific weight and v_2 and v_1 are the point velocities in the two cross sections. Introducing the relations, $dq_2 = v_2\, da_2$ and $dq_1 = v_1 da_1$, the change of momentum then becomes $(w/g)\ (\int v^2_2\, da_2 - \int v^2_1 da_1)$. This in turn is equal to $(w/g)\ (A_2 C_2\ V^2_2 - A_1\ C_1\ V^2_1)$ where C_2 is equal to $(1/A_2)\ [\int\int (v^2_2/V^2_2)\ dx\ dy]$ and V_2 is the mean velocity in a cross section of area A_2. There is a corresponding expression for C_1.

For practical use the equation between pressure and momentum would appear in the following familiar form, in terms of cubic feet:

$$\frac{P_2}{w} + \frac{Q}{g} C_2 V_2 = \frac{P_1}{w} + \frac{Q}{g} C_1 V_1. \quad \ldots\ldots\ldots [1]$$

which can easily be solved graphically by plotting two curves and finding their intersection.

The coefficient C resembles the coefficient α, which occurs in the expression for velocity head, $h = \alpha V^2/2g$, where $\alpha = (1/A)\ [\int\int (v^3/V^3)\ dx\ dy]$.

The second point concerns the transverse level of the stream just downstream from the jump. Where depths upstream are not uniform, each element of channel width will have its own particular height of jump; hence the water surface below the jump will not be plane, and there will be standing waves with some transverse flow. This also is a point that cannot be treated quantitatively in the present state of our knowledge of the subject.

J. B. MACPHAIL, Assoc. M. Am. Soc. C.E.
Civil Engineer, Shawinigan Water and Power Company

Montreal, Canada
November 17, 1933

Sheet-Piling Design

TO THE EDITOR: Writers on the subject of sheet-piling design all agree that lack of certainty in assumptions prevents a theoretical solution. Approximations are made to supply the unknowns, as in the article by Mr. Pennoyer in the November issue. However, such approximations should conform to the established laws of mechanics and at the same time should be controlled by known experimental data and logical deductions therefrom. The article by Mr. Pennoyer errs somewhat in not complying with these requirements.

As far as determination of the active lateral pressure is concerned, all authors agree on the formula, $p = w \tan^2 (45 \text{ deg} - {}^1/_2\phi)$. This is usually given as a special case of the original wedge theory for the condition of a horizontal, non-cohesive fill and a vertical, frictionless wall. Neither Coulomb nor Rankine even suggests that ϕ is the angle of repose; both are very careful to define it as the angle whose tangent is the coefficient of internal friction in the granular mass.

The diagrams in Mr. Pennoyer's Fig. 2 must be used with great caution. Not only is the incorrect definition of ϕ given, but the formula will not give the correct value of the lateral pressure for cohesive soils. Saturation does not eliminate cohesion; quite the contrary is the case in most soils. The method for considering the effect of uniform surcharge is neither reasonable nor statically possible. The diagram must show zero pressure at the top of the sheet piling. The location of the point of application of the resultant pressure is of great interest in the design of the sheet piling for the surcharged cases. It may be of interest to note that experiments indicate quite definitely that the point of application is never below the lower third point, but is at about ${}^2/_3\ h$ for the case of horizontal fill and rises to 0.42 h as a maximum with surcharge. The division of load between the wales certainly depends on the location of the resultant pressure.

Saturation affects the weight of the soil and also the coefficient of internal friction, but not in the same way in all soils. The method given by Mr. Pennoyer is fallacious. It appeared in technical literature about twenty years ago, but was later modified by its originator. If a soil is saturated there is complete buoyancy; otherwise there is none. Saturation has practically no effect on the coefficient of internal friction of packed clean sand, and none on pure clay. Its effect on most soils is to decrease the voids between the particles of the mass, by surface tension and expulsion of entrapped air. Field tests are easily performed to determine the weight and frictional coefficient of soils under normal and saturated conditions and should be made for each design.

Pressure diagrams must be continuous; sudden steps are not reasonable. Nature abhors discontinuity as much as she does a vacuum. Correction of the effect of surcharge will eliminate the steps in the diagram.

Resistance to movement of a sheet-piling wall acting as a cantilever, as well as one that is anchored, is obtained by penetration. The balance of forces must be checked. If the author had tried to apply some of his deductions to the case of sheet piling without an anchor, he would have eliminated some of the loading diagrams in his Fig. 3 as statically impossible assumptions.

Liquids are unique in having equal lateral pressure and resistance to lateral pressure when unbounded in extent. Therefore to talk of a "passive liquid pressure" helps but little to clarify or describe the true action. The resistance is not a "passive liquid pressure"; it does not increase directly with the depth. However, it has a maximum value at each depth. This last fact is not taken into account in Mr. Pennoyer's Fig. 4.

JACOB FELD, Assoc. M. Am. Soc. C.E.
Consulting Engineer

New York, N.Y.
November 17, 1933

Reservoirs Increase Maximum Run-Off

DEAR SIR: With much interest I have read the paper in the April issue on the Arizona Code for Dams. In one regard practice in Java differs from the generally accepted rule. It is customary in most countries to calculate reservoir spillways on the assumption that after the reservoir has been filled the maximum run-off will be the same as before. However, this cannot be true for two reasons. First, the run-off coefficient of the reservoir area will be 100 per cent when the reservoir is full. Of more importance, however, is the change that takes place in the hydrology of the watershed. The propagation velocity of waves in an open body of water being much greater than the normal velocity of water flowing in a stream channel, even in large reservoirs any drop of water reaching the surface will very soon cause an even rise in the level of the whole. The result is that the reservoir causes the flood period to decrease. This may be of considerable importance if the watershed is divided by the reservoir into long narrow strips. As the total run-off is greater than it was before the reservoir was filled, the maximum flood must have increased.

In two cases I found the difference to be between 30 and 100 per cent; so this influence cannot be considered negligible. To estimate its magnitude the watershed should be divided into a large number of small areas, and the mean distance to the dam site and to the reservoir surface should be calculated for each. The difference between the mean distance and the maximum distance the flood must travel in these two cases suggests a possible way to estimate the decrease in flood duration. This factor will be of more importance, the shorter the duration of the storm rainfall causing the flood.

IR. D. H. ARENDS
Engineer, Irrigation Service

Tegal, Java
October 30, 1933

Eighty-First Annual Meeting

New York, N.Y., January 17–20, 1934—Program of Sessions, Entertainment, and Trips

Business Meeting, Prize Awards, and Committee Reports

WEDNESDAY—January 17, 1934—Morning

AUDITORIUM

9:00 Registration

10:00 Eighty-first Annual Meeting called to order by

ALONZO J. HAMMOND, *President, American Society of Civil Engineers; Consulting Engineer*, Chicago, Ill.

10:10 Report of the Board of Direction
Report of the Secretary
Report of the Treasurer

10:25 Conferring of Honorary Membership

F. E. TURNEAURE, *M. Am. Soc. C.E., Dean, College of Mechanics and Engineering, University of Wisconsin; Consulting Engineer*, Madison, Wis. Dean Turneaure will be presented to the President by OTIS E. HOVEY, *M. Am. Soc. C.E., Consulting Engineer, American Bridge Company*, New York, N.Y.

10:40 Presentation of Society Medals and Prizes

The Norman Medal to HARDY CROSS, *M. Am. Soc. C.E., Professor of Structural Engineering, University of Illinois*, Urbana, Ill., for Paper No. 1793, "Analysis of Continuous Frames by Distributing Fixed-End Moments."

The J. James R. Croes Medal to EARL I. BROWN, *M Am. Soc. C.E., Colonel, Corps of Engineers, U.S.A., Board of Engineers for Rivers and Harbors*, Washington, D.C., for Paper No. 1805, "Flow of Water in Tidal Canals."

The Thomas Fitch Rowland Prize to the late JOHN C. BAXTER, *M. Am. Soc. C.E.*, who was *Contractor and Engineer, Carey, Baxter and Kennedy, Inc.*, New York, N.Y., for Part III of Paper No. 1809, "The Eight-Mile Cascade Tunnel, Great Northern Railway; Construction Plans and Methods."

The James Laurie Prize to W. B. SAUNDERS, *M. Am. Soc. C.E., Hydraulic Engineer, Andes Copper Mining Company*, Barquito, Chañaral, Chile, for Paper No. 1795, "Construction of La Ola Pipe Line."

The Arthur M. Wellington Prize to D. J. KERR, *M. Am. Soc. C.E., Assistant to Vice-President, Operating Department, Great Northern Railway*, St. Paul, Minn., for Part I of Paper No. 1809, "The Eight-Mile Cascade Tunnel, Great Northern Railway; Preliminary Studies and Results of Improving Cascade Crossing."

The Collingwood Prize for Juniors to BERNARD L. WEINER, *Assoc. M. Am. Soc. C.E.*, New York, N.Y., for Paper No. 1815, "Design of a Reinforced Concrete Skew Arch."

The Alfred Noble Prize to C. MAXWELL STANLEY, *Jun. Am. Soc. C.E., Engineer, Young and Stanley, Inc.*, Muscatine, Iowa, for Paper on "Study of Stilling Basin Design."

12:00 Presentation of the John Fritz Medal

To the late JOHN R. FREEMAN, *Past-President and Honorary Member, Am. Soc. C.E.*

Introduction of WILLIAM H. BASSETT, *Former President, American Institute of Mining and Metallurgical Engineers, Chairman of the John Fritz Medal Board of Award*, by ALONZO J. HAMMOND, *President Am. Soc. C.E.*

Statement by CHAIRMAN BASSETT on the history and purpose of the medal.

Address on the achievements of the medalist by THADDEUS MERRIMAN, *M. Am. Soc. C.E., and member of the board which made the award.*

Presentation of the John Fritz Medal to JOHN R. FREEMAN, JR., by FRANCIS LEE STUART, *Past-President Am. Soc. C.E., Chairman of the board which made the award.*

Response by JOHN R. FREEMAN, JR.

12:15 Presentation of Reports of Committees

COMMITTEE ON CONCRETE AND REINFORCED CONCRETE ARCHES

CLYDE T. MORRIS, *M. Am. Soc. C.E., Professor of Structural Engineering, Ohio State University*, Columbus, Ohio, *Chairman.*

COMMITTEE ON EARTHS AND FOUNDATIONS

LAZARUS WHITE, *M. Am. Soc. C.E., President, Spencer, White and Prentis, Inc.*, New York, N.Y., *Chairman.*

COMMITTEE ON IRRIGATION HYDRAULICS

D. C. HENNY, *Vice-President and M. Am. Soc. C.E., Consulting Engineer*, Portland, Ore., *Chairman.*

COMMITTEE ON METEOROLOGICAL DATA

DONALD M. BAKER, *M. Am. Soc. C.E., Consulting Engineer*, Los Angeles, Calif., *Chairman.*

12:30 New Business

Report of Tellers on Canvass of Ballot for Officers

Introduction of President-Elect

12:45 Luncheon

Fifth Floor, Engineering Societies Building. Tickets $1.00 each.

Use Railroad Certificate to Obtain Reduced Fare. Consult Your Ticket Agent for Selling Date in Your Territory.

General Session—President's and Honorary Member's Dinner, Reception, and Dance

WEDNESDAY—January 17, 1934

Afternoon

GENERAL MEETING

AUDITORIUM

Arranged Under Auspices of
Engineering-Economics and Finance Division

2:30 The Equitable Theory of Governmental Ownership and Operation

FREDERICK H. MCDONALD, *M. Am. Soc. C.E., Consulting Engineer*, Atlanta, Ga.

3:00 Discussion opened by

JAMES P. GIFFORD, *Esq., Attorney-at-Law; Assistant Professor of Law and Assistant to the Dean, Columbia Law School*, New York, N.Y.

E. P. GOODRICH, *M. Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

CHARLES KELLER, *M. Am. Soc. C.E., Brigadier General, U.S.A. (Retired), with Byllesby Engineering and Management Corporation*, Chicago, Ill.

Evening

DINNER DANCE

HOTEL ROOSEVELT

Committee: EMIL PRAEGER, *Chairman*, WILLIAM J. BARNEY and WILLIAM MCK. GRIFFIN

7:00 Assembly
7:30 Dinner
9:30 Reception to the President and Honorary Members
10:00 Dancing

This function will be held at the Hotel Roosevelt, Madison Avenue and 45th Street, the Grand Ballroom to open at 7:00 p.m., and the dinner to be served promptly at 7:30 p.m.

Arrangements have been made for tables seating ten persons, and members may underwrite complete tables. Orders to underwrite a table must be accompanied by check in full and a list of guests.

Tickets will be $5.00 each.

Tickets for Juniors, for the dance only, will be $2.00 per couple.

The seating for the dinner dance list will close at 5:00 p.m., Tuesday, January 16, 1934. Those who purchase tickets after that hour will be assigned to tables in the order of their purchase. Tickets will be on sale at Society Headquarters until 5:00 p.m., Wednesday, January 17, 1934.

Sessions of Technical Divisions Occupy Entire Day

THURSDAY—January 18, 1934—Morning

CITY PLANNING DIVISION

AUDITORIUM

10:00 Benefits and Advantages of National Planning with Reference to Emergency Conditions

CAREY H. BROWN, *M. Am. Soc. C.E.*, Washington, D.C.

10:20 How National Planning Can Help In:

a) **The Development of the Major Highway System**

E. W. JAMES, *M. Am. Soc. C.E., Chief, Division of Design, Bureau of Public Roads*, Washington, D.C.

10:40 *b)* **Development and Coordination of Rail, Highway, and Waterway Systems**

C. O. SHERRILL, *M. Am. Soc. C.E., City Manager*, Cincinnati, Ohio.

11:00 *c)* **Conservation of Natural Resources**

ARTHUR E. MORGAN, *M. Am. Soc. C.E., Director, Tennessee Valley Authority*, Knoxville, Tenn.

11:20 Discussion

REGIONAL MEETING COMMITTEE

This program has been prepared under the direction of the Regional Meeting Committee: Arthur S. Tuttle, Vice-President Am. Soc. C.E., Chairman; and Henry R. Buck, L. G. Holleran, Charles A. Mead, J. P. H. Perry, and James F. Sanborn, Directors Am. Soc. C.E.

CONSTRUCTION DIVISION

ROOM 1, FIFTH FLOOR

10:00 Reports of Committees

10:30 Functions of the Construction Engineer (A Symposium)

a) **The Engineering Viewpoint**

HERBERT S. CROCKER, *Past-President, Am. Soc. C.E., Consulting Engineer*, Denver, Colo.

11:00 *b)* **The Field Construction Viewpoint**

A. P. GREENSFELDER, *M. Am. Soc. C.E., President, Fruin-Colnon Contracting Company*, St. Louis, Mo.

11:30 Constructive Engineering

HUGH MILLER, *M. Am. Soc. C.E., State Engineer, Federal Emergency Administration of Public Works*, St. Louis, Mo.

12:00 Discussion

Members Are Urgently Requested to Make Early Reservations for All the Functions in Order to Facilitate the Work of the Committee in Completing Arrangements.

THURSDAY—January 18, 1934—Morning (Continued)

SANITARY ENGINEERING DIVISION

ROOM 2, FIFTH FLOOR

10:00 On the Flow of Water Through Sand

GORDON M. FAIR, *M. Am. Soc. C.E., Associate Professor of Sanitary Engineering, Harvard University,* Cambridge, Mass.

10:30 Discussion

10:45 Underground Corrosion

K. H. LOGAN, *Esq., Chief, Underground Corrosion Section, Bureau of Standards,* Washington, D.C.

11:15 Discussion

11:30 Committee Reports

Committee on Filtering Materials: W. E. STANLEY, *Assoc. M. Am. Soc. C.E., Hydraulic and Sanitary Engineer, Pearse, Greeley and Hansen,* Chicago, Ill., *Chairman.*

Committee on Salvage of Sewage: A. M. RAWN, *M. Am. Soc. C.E., Assistant Chief Engineer, Los Angeles County Sanitation Districts,* Los Angeles, Calif., *Chairman.*

Committee on Water Supply Engineering: THOMAS H. WIGGIN, *M. Am. Soc. C.E., Consulting Engineer,* New York, N.Y., *Chairman.*

THURSDAY—January 18, 1934—Afternoon

HIGHWAY DIVISION

ROOM 1, FIFTH FLOOR

2:30 Traffic Influence of the West Side Elevated Highway, New York, N.Y.

BENJAMIN SCHWERIN, *Assoc. M. Am. Soc. C.E., Assistant Engineer, Department of Public Works of Manhattan,* New York, N.Y.

3:00 Discussion

3:15 New Jersey State Highway Approach to Holland Tunnel

W. G. SLOAN, *M. Am. Soc. C.E., State Highway Engineer, State Highway Commission,* Trenton, N.J., and S. JOHANNESSON, *M. Am. Soc. C.E., Designing Engineer, State Highway Commission,* Trenton, N.J.

3:45 Discussion

WATERWAYS DIVISION

ROOM 2, FIFTH FLOOR

2:30 Field Verification of Hydraulic Laboratory Results

HERBERT D. VOGEL, *Assoc. M. Am. Soc. C.E., Lieutenant, Corps of Engineers, U.S.A., Assistant to President, Mississippi River Commission,* Vicksburg, Miss.

3:00 Discussion

K. C. REYNOLDS, *Assoc. M. Am. Soc. C.E., Assistant Professor, Hydraulics, Department of Civil and Sanitary Engineering, Massachusetts Institute of Technology,* Cambridge A, Mass.

H. N. EATON, *Esq., Acting Chief, Hydraulic Section, U.S. Bureau of Standards,* Washington, D.C.

EMIL P. SCHULEEN, *Assoc. M. Am. Soc. C.E., Assistant Engineer, U.S. Engineer Office,* Pittsburgh, Pa.

3:30 Littoral Drift

J. J. HENNEBIQUE, *M. Am. Soc. C.E., Consulting Engineer,* Accord, N.Y.

STRUCTURAL DIVISION

AUDITORIUM

2:30 Report of the Committee on Bridge Floors

SHORTRIDGE HARDESTY, *M. Am. Soc. C.E., Consulting Engineer, Waddell and Hardesty,* New York, N.Y.

2:50 Report of Committee on Concentrated Loads on Concrete Slabs

C. T. MORRIS, *M. Am. Soc. C.E., Professor of Structural Engineering, Ohio State University,* Columbus, Ohio.

3:10 Reconstruction of the Smithfield Street Bridge, Pittsburgh, with Aluminum Floor

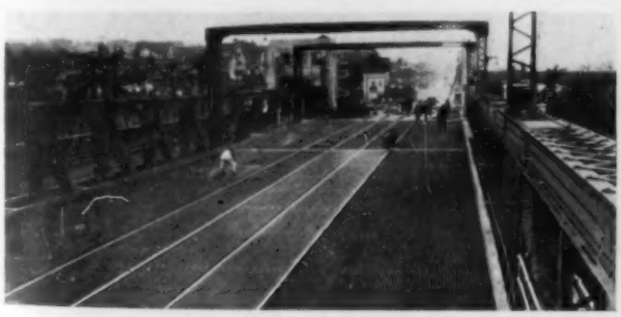
J. P. GROWDON, *M. Am. Soc. C.E., Assistant Chief Hydraulic Engineer, Aluminum Company of America, Pittsburgh, Pa.,* and R. M. RIEGEL, *M. Am. Soc. C.E.,* Pittsburgh, Pa.

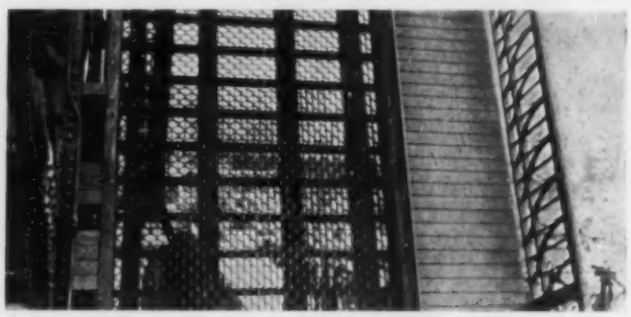
3:30 Discussion by

MORRIS GOODKIND, *M. Am. Soc. C.E., Bridge Engineer, State Highway Commission,* Trenton, N.J.

ALLSTON DANA, *M. Am. Soc. C.E., Engineer of Design, The Port of New York Authority,* New York, N.Y.

LEON S. MOISSEIFF, *M. Am. Soc. C.E., Consulting Engineer,* New York, N.Y.





OPEN-GRATING BRIDGE FLOOR OF LIGHT WEIGHT INSTALLED ON UNIVERSITY BRIDGE, SEATTLE, WASH.

Entertainment for the Ladies—Smoker for the Men

THURSDAY—January 18, 1934—Afternoon and Evening

FASHION SHOW AND TEA

GRAND BALLROOM, HOTEL ROOSEVELT

Committee: DAVID BONNER, *Chairman*, and CHARLES E. TROUT

4:00 Face, Figure, and Fashion Show

How any woman can be beautiful in ten minutes
Fashion and figures (correct posture)
Reducing exercises
Coiffure
Fashion show, rhythmic dancing

5:15 Tea

Following the fashion show, tea will be served at the Hotel Roosevelt.

7:00 Buffet Supper

At Engineering Woman's Club, Inc., 123 East 37th Street. Supper will be followed by cards for those who desire to play.

Through the courtesy of the Engineering Woman's Club, Inc., 123 East 37th Street, the facilities of that club will be available to the ladies during the entire Annual Meeting.

All ladies are especially invited to make the Club their headquarters. Members of the Ladies Committee will be at the Club to assist visiting ladies in getting acquainted and to furnish information about shopping, sightseeing, or other points of interest.

There will be an information desk for ladies at Society Headquarters. All ladies are requested to avail themselves of the facilities of the Society or the Engineering Woman's Club.

THURSDAY—January 18, 1934—Evening

ADDRESS AND SMOKER

AUDITORIUM

Committee: BILLINGS WILSON, *Chairman*, C. W. BRYAN, JR., and PHILIP KEENE

8:00 Address on Aerial Photography by

CAPT. ALBERT W. STEVENS, *Air Corps, U.S.A., Wright Field*, Dayton, Ohio.

Captain Stevens, who is one of the outstanding experts in this field, will illustrate his address with lantern slides, some of which are reproductions of photographs taken when his plane was more than 300 miles from the objects shown.

Following the address, smokes and refreshments will be served on the fifth floor.

Tickets for the Smoker and evening's entertainment are free to members. Guest tickets are $2.00 each.

Sanitary Engineers' Annual Meeting and Dinner

TUESDAY—January 16, 1934—All Day

New York State Sewage Works Association

The New York State Sewage Works Association will hold its annual meeting on Tuesday, January 16, 1934, in the Colonial Room of the Hotel McAlpin, New York, N.Y.

This meeting will convene at 9:00 a.m., and there will be a luncheon at 12:30 p.m. in the same rooms. In the evening the members will meet jointly with the Sanitary Engineering Division of the Society at its annual dinner at the Hotel McAlpin. The Technical Sessions will be devoted to a discussion of the operation of sewage works.

TUESDAY—January 16, 1934—Evening

Annual Dinner of Sanitary Engineering Division

The Annual Dinner of the Sanitary Engineering Division of the Society will be held on Tuesday, January 16, 1934, at 7:00 p.m., at the Hotel McAlpin, Broadway and 34th Street, New York, N.Y. Abel Wolman, M. Am. Soc. C.E., Chief Engineer, State Department of Health, Baltimore, Md., will give an address on "Some Observations on PWA and CWA Programs." The charge per cover will be $3.00. Reservations should be made not later than January 13, 1934, through Richard H. Gould, Department of Sanitation, 54 Lafayette Street, New York, N.Y.

MANHATTAN ISLAND FROM AN ELEVATION OF 15,000 FT, TAKEN DECEMBER 10, 1933

(1) U. S. Navy Yard, Brooklyn, N.Y.; (2) Holland Tunnel Ventilator Shafts; (3) Commerce Building, The Port of New York Authority; (4) West Side Elevated Highway; (5) Transatlantic Pier Terminals (under construction); (6) Society Headquarters; (7) Rockefeller Center, Radio City; (8) Triborough Bridge Construction; (9) The George Washington Bridge

College Reunions Throughout the Week

Numerous Alumni Gatherings Scheduled for Visiting Engineers

JANUARY 18 TO 20, 1934

THURSDAY—January 18, 1934

Brown Engineering Association

The Brown Engineering Association will hold an informal luncheon meeting at the Hotel Wentworth, 59 West 46th Street, New York, N.Y., on Thursday, January 18, 1934, at 12:30 p.m. All Brown alumni are invited. The charge will be 50 cents per cover. Please call Charles G. Burgess (Vanderbilt 3-8000) not later than 5:00 p.m., January 17, if you plan to attend.

Dinner of Columbia Engineers

The graduates of Columbia University who are members of the Society will meet for an informal dinner on Thursday, January 18 1934, at 6:15 p.m., at the Columbia University Club, 4 West 43d Street, New York, N.Y. A motion picture film entitled "The Story of a Topographic Map," taken at Camp Columbia, the Summer School of Surveying, will be shown. The charge will be $1.25 per cover. Address communications to Prof. J. K. Finch, Columbia University, New York, N.Y.

Lafayette College Civil Engineers Dinner

All civil engineers of Lafayette College are invited to attend an informal dinner on Thursday, January 18, 1934, at 6:00 p.m., at the Grill Room of the Happiness Restaurant, 6 East 39th Street, New York, N.Y. The charge will be $1.10 per cover. If you plan to attend, please notify William R. Wolff, 2 Adrian Avenue, New York, N.Y.

Lehigh University Civil Engineers Dinner

All Lehigh University engineers, members of the Society, are invited to an informal dinner to be held at the Canadian Club, Waldorf-Astoria Hotel, on Thursday, January 18, 1934, at 6:00 p.m. The dinner will cost $1.75 per cover.

The facilities of the Club will be available to all Lehigh men during the late afternoon and evening. Dinner will be over in time for guests to attend the Society Smoker.

Please promptly notify Alexander Potter, 50 Church Street, New York, N.Y., if you can be present.

The committee hopes for a full attendance at this first dinner of Lehigh members held after a lapse of many years.

New York University Alumni Reunion Dinner

The New York University Alumni Reunion Dinner will be held at Rutley's Grill, 1440 Broadway, New York, N.Y., on Thursday evening, January 18, 1934. There will be a social meeting at 5:30 p.m., followed by dinner at 6:30. The charge will be 75 cents per cover. Please make reservations through Thomas Mass, 1715 Nelson Avenue, Borough of the Bronx, New York, N.Y. (Foundation 8-4255).

Luncheon of M. I. T. Engineers

All M. I. T. alumni are invited to a luncheon meeting of the Technology Club of New York on Thursday, January 18, 1934, at 12:30 p.m., at the Club rooms, 22 East 38th Street, New York, N.Y. Please notify the Technology Club (Caledonia 5-1475) as to attendance.

University of Illinois Engineers Dinner

All University of Illinois engineers, and their friends, are invited to the Sixth Annual Informal Dinner-Reunion at the Hotel Woodstock, 127 West 43d Street, New York, N.Y., on Thursday, January 18, 1934, at 5:45 p.m., in the Elizabethan Grill.

The dinner will cost $1.00 and will be over in time for guests to attend the Society's Smoker. If you plan to attend, please notify Martin E. Jansson, care, D. Van Nostrand Company, Publishers, 250 Fourth Avenue, New York, N.Y.

University of Pennsylvania Civil Engineers Dinner

The Fifteenth Annual Informal Dinner of the University of Pennsylvania Civil Engineers will be held at the University of Pennsylvania Club, 35 East 50th Street, New York, N.Y., on Thursday, January 18, 1934, from 6:00 to 7:30 p.m. The dinner fills in the time from the end of the Technical Session at 5:00 p.m. until the commencement of the Smoker at 8:00 p.m. Dinner will be served at 6:00 p.m. sharp, in the main dining room of the Club.

The charge per cover will be $1.00. Any further information can be obtained from William G. Grove, M. Am. Soc. C.E., care, Robinson and Steinman, Room 1104, 117 Liberty Street, New York, N.Y.

FRIDAY—January 19, 1934

Cornell Dinner

There will be an informal dinner meeting with news from the campus for visiting Cornell engineers and local members of the Cornell Society of Engineers on Friday, January 19, 1934, at 6:30 p.m., at the Cornell Club of New York, 245 Madison Avenue, New York, N.Y. Added attraction will also be provided. Please notify E. C. M. Stahl, 380 Pearl Street, Brooklyn, N.Y., of your intention to be present.

Harvard-Yale-Princeton Joint Meeting

The 1934 joint meeting of the Harvard Engineering Society and the Yale and Princeton Engineering Associations will be held on Friday evening, January 19, 1934. The Yale Engineering Association will be host for the evening. The meeting will be held at the Yale Club, 50 Vanderbilt Avenue, New York, N.Y., and an interesting program has been arranged for the evening. Members of these societies in the Metropolitan District and from out of town are invited to be present, and they are assured of a very enjoyable time. No charge will be made.

Thayer Society of Engineers of Dartmouth College

The annual meeting and dinner of the Thayer Society of Engineers of Dartmouth College will be held at the Dartmouth College Club, New York, N.Y., at 6:30 p.m., Friday, January 19, 1934. Notify the Dartmouth College Club, 24 East 38th Street, New York, N.Y., as to attendance.

Union College Engineers Dinner

The annual dinner of the Union College Engineers will be held at the Phi Gamma Delta Club, 106 West 56th Street, New York, N.Y., at 6:30 p.m., Friday, January 19, 1934. Reservations may be made through H. Garnett Davis, care, Francisco and Jacobus, 511 Fifth Avenue, New York, N.Y.

SATURDAY—January 20, 1934

Clarkson College Alumni Dinner Meeting

The annual dinner and business meeting of the Clarkson College Alumni Association will be held at the Hotel McAlpin, New York, N.Y., on Saturday, January 20, 1934. The business meeting will be held in Room E at 2:00 p.m., to which all alumni members are invited. The dinner will be held in the Blue Room at 6:30 p.m. The charge per cover will be $3.00. Notify Frank C. Boes, 38 Cypress Street, Floral Park, N.Y., as to attendance.

All-Day Excursion to Rockefeller Center

FRIDAY—January 19, 1934—Morning and Afternoon

9:30 All-Day Excursion to Rockefeller Center

EXCURSION COMMITTEE

E. R. NEEDLES, *Chairman*, EDWARD ANDERBERG and ROBERT H. JACOBS

Through the courtesy of the management, arrangements have been made for a visit to Rockefeller Center, well known as an outstanding example of city planning of skyscrapers devoted to specific uses.

Members and guests will have the unusual privilege of visiting a number of points of interest, for which arrangements could not be made as individuals. The group will assemble at the entrance to the Music Hall at 50th Street and Sixth Avenue at 9:30 sharp. Of particular interest in the Music Hall, which is the largest theater in the world, are the murals, the orchestra bandwagon, the stage elevator, the proscenium arch, and the backstage arrangements. There will be opportunity also for an inspection of the International Buildings, which include the British Empire Building, La Maison Française, and the Palazzo d'Italia.

Following the visit to the Music Hall, the party will go to the 70-story R.C.A. Building, where members and guests in groups will be shown the broadcasting facilities. Engineers of the broadcasting company will be assigned to explain technical details. Other points of interest in the Radio Corporation of America Building are the murals, the stone cutting, and the observation roof. Luncheon will be served at 12:45 on the 63d floor of the R.C.A. Building, following which the entire group will attend the afternoon performance in the Music Hall, for which seats have been reserved.

Tickets for the entire trip, including luncheon, the inspection trips, and the entertainment, are $2.75 each.

12:45 Luncheon in the R.C.A. Building

To be followed by attendance at afternoon performance at the Radio City Music Hall, cost of which is included in tickets for the trip.

ROCKEFELLER CENTER, NEW YORK, LOOKING WEST, AS IT WILL APPEAR WHEN COMPLETED

The Buildings Now Finished Are the Towering Central R.C.A. Building; the 31-Story RKO Building, and the Radio City Music Hall, Which Adjoins It on the East; the RKO Roxy Theater at the West of the South Block; and the British and the French Buildings, Both Six Stories, Facing on Fifth Avenue in the Central Foreground. Architectural Rendering by John Wenrich

Trips to Points of Engineering Interest

SATURDAY—January 20, 1934—Morning

10:00 Inspection Trips

Arrangements have been made for visits to the following points of engineering interest. As these trips all start about the same hour, it will not be possible to participate in more than one. Members will proceed individually to the rendez vous point named for the trip selected, so as to arrive at the time given.

1. New York Museum of Science and Industry, 220 East 42d Street, Manhattan.
2. Commerce Building, Port of New York Authority, at Eighth and Ninth Avenues, 15th to 16th Streets, Manhattan.
3. U. S. Navy Yard, Brooklyn, N.Y.

New York Museum of Science and Industry

Through the courtesy of the officers of the Museum, which is at 220 East 42d Street, arrangements have been made for members, ladies, and guests to visit this most interesting display. Among the 11 permanent-exhibit divisions of particular interest to engineers are those described below.

Railroad Transportation: A full-sized replica of *The Rocket*, models of locomotives and passenger and freight cars, tools, accessories, and parts of engines and cars.

Marine Transportation: Models of sailing and steamships from Phœnician and Greek vessels to the *Bremen;* operating models of marine engines, apparatus, and maps.

Aviation: Models of airplanes, an actual plane, instruments, engines, exhibits illustrating the physical principles of flying.

Communication: Models and apparatus, chiefly operating; diagrams, paintings illustrating the development of communication from sign language to radio.

Power: Engines, turbines, models, dioramas, and charts tracing the steps in harnessing water, steam, and electricity to do man's work.

Electrical Science and Technology: Fundamental principles of electrical science, epoch-making discoveries, and industrial applications illustrated, chiefly by operating exhibits.

Machine Tools: Replicas and original machines show the development of machines that make machines.

Other exhibits, of interest to ladies, include food industries, clothing, textiles, dwellings, glass making, and the development of artificial lighting.

U. S. NAVY YARD, BROOKLYN, NEW YORK

Commerce Building, Port of New York Authority

Members visiting the Commerce Building will go to 111 Eighth Avenue, where they will be met and conducted over the building. The Seventh Avenue and Eighth Avenue subways or the Ninth Avenue Elevated to 14th Street, Manhattan, are convenient.

This building combines a Union Inland Freight Station for less-than-carload freight, with 14 floors of commercial space available for lofts, light manufacturing, show rooms, and offices. In cubic capacity, it is the largest structure on Manhattan Island. Among other innovations, it contains four of the largest high-duty elevators ever built, with platforms 17 by 34 ft.

COMMERCE BUILDING, THE PORT OF NEW YORK AUTHORITY

U. S. Navy Yard

The Navy Yard may be reached via Graham Avenue or Flushing Avenue street cars taken at the New York end of the Brooklyn Bridge, thence to the Cumberland Street gate of the Navy Yard. In going to the Navy Yard by automobile, cross the Manhattan Bridge and turn left at the Brooklyn end, proceeding by Flushing Avenue to the Cumberland Street gate.

The following are some points of interest at the Navy Yard:

Four types of dry dock: one with granite facing; a second with timber facing; another on which the side walls have been replaced with a reinforced concrete slab tied back into a relieving platform below the surface at the back of the wall, with the bottom reaction taken by timber struts in the floor of the dock; and a fourth in which the walls are faced with brick. Machine shops where engines of various types are constructed; boiler shops; foundry; central power plant; testing laboratory Shipways, cranes, derricks. Opportunity to see but not to go aboard the 10,000-ton cruiser, *New Orleans*, which is nearing completion, and a destroyer under construction. On account of Navy Department Regulations, only American citizens can be admitted.

Announcements—Reduced Railroad Rates

Reduced rates on the Identification Certificate Plan have been granted by the passenger associations of the United States and the lines of the Canadian Passenger Association.

A certificate authorizing purchase, at starting point, of round-trip tickets at reduced rates has been mailed to the membership of the Society.

Selling dates for tickets in the territory of the Trunk Line, the New England, the Central, and the Southeastern Passenger Association are January 11 to 19.

In the territory of the Southwestern, the Western, the Trans-Continental, and the Canadian Passenger Association, the opening dates of sale vary from January 8 to 13, and the closing dates from January 16 to 19, depending upon location and travel.

As certificates cannot be used after the closing date of sale, those planning to attend should consult their local ticket agents about selling dates in their territories.

ments. Ticket order blanks have been mailed to each member with a railroad certificate and condensed program.

No cancellation of tickets can be made after noon of Wednesday, January 17, 1934.

Introductions for Visiting Members

Members who during their attendance at the Annual Meeting wish introductions or meetings with engineers in New York, N.Y., may call on the Secretary's Office for any service desired.

Your New York Address

At the Registration Desk, a card file of those in attendance will be maintained, with information as to members' hotel addresses in New York. Members are requested to keep Headquarters informed as far as possible of such addresses so as to expedite the delivery of telegrams, telephone messages, and mail.

Committee on Local Arrangements for the Annual Meeting

WILLIAM J. SHEA, *Chairman*
WILLIAM MCK. GRIFFIN, *Vice-Chairman*

EDWARD ANDERBERG
W. J. BARNEY
DAVID BONNER
C. W. BRYAN, JR.
ROBERT H. JACOBS
PHILIP KEENE
ENOCH R. NEEDLES
EMIL PRAEGER
CHARLES E. TROUT
BILLINGS WILSON

Ladies Committee

MRS. ALONZO J. HAMMOND, *Honorary Chairman*
MRS. DAVID BONNER, *Chairman*
MRS. WILLIAM J. SHEA, *Vice-Chairman*
MRS. EDWARD ANDERBERG
MRS. W. J. BARNEY
MRS. V. T. BOUGHTON
MRS. C. W. BRYAN, JR.
MRS. HENRY R. BUCK
MRS. R. E. DOUGHERTY
MRS. HARRISON P. EDDY
MRS. WILLIAM MCK. GRIFFIN
MRS. JOHN P. HOGAN
MRS. L. G. HOLLERAN
MRS. OTIS E. HOVEY
MRS. ROBERT H. JACOBS
MRS. GEORGE L. LUCAS
MRS. CHARLES A. MEAD
MRS. THADDEUS MERRIMAN
MRS. ENOCH R. NEEDLES
MRS. FREDERICK C. NOBLE
MRS. J. P. H. PERRY
MRS. MALCOLM PIRNIE
MRS. EMIL PRAEGER
MRS. ROBERT RIDGWAY
MRS. GEORGE T. SEABURY
MRS. JOHN R. SLATTERY
MRS. E. W. STEARNS
MRS. D. B. STEINMAN
MRS. CHARLES E. TROUT
MRS. ARTHUR S. TUTTLE
MRS. BILLINGS WILSON

Please call on the Committee on Local Arrangements or the Secretary's Office for any service desired.

Hotel Rates

Hotels	Without Private Bath		With Private Bath	
	Single Room	Double Room	Single Room	Double Room
Roosevelt	.....	.....	$4.00 up	$6.00 up
Astor	$2.00–2.50	$3.00–3.50	3.00 up	4.00 up
Commodore	.....	.....	3.00–6.00	4.50–10.00
Lexington	.....	.....	3.00 up	4.00– 5.00
McAlpin	2.00 up	3.50 up	2.50 up	4.00 up
Murray Hill	2.00 up	3.00 up	2.50 up	3.50– 7.00
New Yorker	.....	.....	3.50–8.00	5.00–10.00
Pennsylvania	.....	.....	3.50 up	5.00 up
Plaza	.....	.....	5.00–7.00	7.00–10.00
Prince George	.....	.....	2.50–4.00	3.50– 6.00
Savoy-Plaza	.....	.....	5.00 up	7.00 up
Taft	.....	3.00 up	2.50 up	3.50 up
Vanderbilt	.....	.....	3.00 up	6.00 up
Waldorf-Astoria	.....	.....	6.00–9.00	9.00–14.00
Wellington	2.00 up	3.00 up	2.50 up	3.50 up
Woodward	.....	.....	2.50 up	3.50 up

NOTE: The Hotel Roosevelt, at which the reception, dinner, and dance will be held, will care for reservations to the extent of its capacity.

Hotel Accommodations

In order to be certain of accommodations, members are urged to make definite arrangements for rooms at least a week in advance of the Annual Meeting, paying for the rooms in advance for a part of the period during which they expect to be in New York.

Facilities of the Engineers Club for Out-of-Town Members

For the convenience of out-of-town members, the committee has made arrangements with the Engineers Club for luncheon and dinner on Thursday, January 18, 1934. The luncheon tickets are 75 cents each and the dinner tickets are $1.25 each, and will be on sale at the Registration Desk. The Club will also be able to accommodate a limited number of members, the price of rooms ranging from $2.50 upward. Requests for room reservations should be made in advance and addressed to Society Headquarters.

Information Desk

An Information Desk is provided in the Reading Room of the Society on the Fifteenth Floor of the Engineering Societies Building to assist visiting members in obtaining hotel reservations, theater tickets, and any other information about the city. Their attention is called to the facilities of the Reading Room (open until 9:00 p.m., Tuesday, Wednesday, and Thursday evenings), for meeting friends, writing letters, and receiving mail. All members are welcome to inspect and utilize the quarters of the Society.

Order All Tickets in Advance

Not only will members who order tickets in advance be saved annoyance and delay by having tickets and badges awaiting them on arrival at Headquarters, but they will assist the committee greatly in giving advance information to guide it in concluding arrange-

© *Nesmith*

CHRYSLER BUILDING FROM BENEATH THE QUEENSBORO BRIDGE

SOCIETY AFFAIRS

Official and Semi-Official

Prize Winners and Medalists

EARL I. BROWN
J. James R. Croes Medal, "Flow of Water in Tidal Canals"

JOHN R. FREEMAN
John Fritz Gold Medal

HARDY CROSS
Norman Medal, "Analysis of Continuous Frames by Distributing Fixed-End Moments"

J. C. BAXTER
Thomas Fitch Rowland Prize, "Eight-Mile Cascade Tunnel — Construction Plans and Methods"

D. J. KERR
Arthur M. Wellington Prize, "Cascade Tunnel — Preliminary Studies and Results of Improving Cascade Crossing"

C. MAXWELL STANLEY
Alfred Noble Prize, "Study of Stilling Basin Design"

W. B. SAUNDERS
James Laurie Prize, "Construction of La Ola Pipe Line"

BERNARD L. WEINER
Collingwood Prize for Juniors, "Design of a Reinforced Concrete Skew Arch"

Prizes and Medals to Be Awarded at the Annual Meeting

AT THE Annual Meeting of the Society, to be held in New York, N.Y., January 17–20, three types of prizes will be presented. First, the usual prizes for particularly meritorious papers published in TRANSACTIONS will be presented to the authors selected by the Society's Committee on Prizes for 1933 and approved by the Board of Direction at its September meeting, as announced in the November issue, page 645. Second, the Alfred Noble Prize, awarded by a joint committee composed of one member each from the four Founder Societies and the Western Society of Engineers, will be presented. This prize goes to the author, under 30 years of age, of a technical paper published in a technical publication of one of these societies. Third, the John Fritz Medal, for notable scientific or industrial achievement, will be presented. It is awarded by a board consisting of one representative of each of the four Founder Societies.

The oldest Society prize, the Norman Medal, dates back to 1872, when it was endowed by the late George H. Norman, M. Am. Soc. C.E., for an original paper judged worthy of special commendation for its merit as a contribution to engineering science. Next in distinction is the J. James R. Croes Medal, established by the Society in 1912 and named for the first recipient of the Norman Medal. It is awarded for the paper considered second in merit to that receiving the Norman Medal.

In 1882 the late Thomas Fitch Rowland, Hon, M. Am. Soc. C.E., endowed the prize that bears his name, to be awarded preferably for the paper which describes in detail some accomplished works of construction, their costs, and errors in design and execution. In 1912 the Society established a prize named in honor of the first President of the Society, the late James Laurie, M. Am. Soc. C.E., for the paper judged to be second in order of merit to that awarded the Thomas Fitch Rowland Prize.

For the best paper on transportation by land, sea, or air, the *Engineering News-Record* in 1921 established and endowed the Arthur M. Wellington Prize. Although this prize is not restricted to members of the Society, its award rests with the Society.

In 1894, on his retirement as Secretary of the Society, the late Francis Collingwood, M. Am. Soc. C.E., endowed a prize for Juniors of the Society. Accuracy of language and excellence of style are factors in the selection of the paper receiving the Collingwood Prize for Juniors. This paper must describe an engineering work or record an important engineering investigation with which the writer has been connected.

Biographical sketches of all those who will receive prizes or medals at the Annual Meeting follow.

JOHN C. BAXTER, M. Am. Soc. C.E., was posthumously awarded the Thomas Fitch Rowland Prize, his death having occurred on July 27, 1933. Mr. Baxter's early experience centered in railroad engineering work in the West, where at the beginning of the century he was prominently identified with pioneer construction projects of the Chicago, Milwaukee and St. Paul, the Great Northern, and the Northern Pacific Railway. In 1912 he left the engineering profession to engage in contracting. Among his important achievements in this field was the supervision of construction of the eight-mile Cascade Tunnel of the Great Northern Railway. Besides his prize-winning paper on this subject, he wrote other technical articles on tunneling. In 1930 he became a partner in the contracting firm of Carey, Baxter and Kennedy, of New York, N.Y., and in December 1932 was made president of that organization, a position which he held until his death.

EARL I. BROWN, M. Am. Soc. C.E., has been in the Corps of Engineers of the U. S. Army since 1898, when he was graduated from the U. S. Military Academy at West Point. He has had a wide range of engineering experience both in the United States and its foreign possessions, his work including such diverse fields as river and harbor improvement; bridge, dam, and road construction; and topographic surveys and military reconnaissances, involving the mapping of 1,800 sq miles. He was an active participant in the World War, in which he served as Division Engineer of the 92d Division, which took part in engagements in the St. Die Sector and in the Argonne offensive. Later he was Chief Engineer of the Fifth Corps of the A.E.F. and finally commanded the 21st Engineers, Light Railways. From July 1930 to December 4, 1933, he was in charge of the U. S. Engineer Office in Philadelphia, with the rank of Colonel, Corps of Engineers, U. S. Army. He is now on duty with the Board of Engineers for Rivers and Harbors, in Washington, D.C.

HARDY CROSS, M. Am. Soc. C.E., after graduation from Hampden-Sydney College, received degrees in engineering from the Massachusetts Institute of Technology and from Harvard University. For several years he taught civil engineering at Brown University. His practice has been connected chiefly with the design and construction of bridges and buildings. Since 1921 he has been Professor of Structural Engineering at the University of Illinois. His writings include several bulletins of that institution and numerous articles on structural engineering. He is senior author of *Continuous Frames of Reinforced Concrete*.

JOHN RIPLEY FREEMAN, Hon. M. Am. Soc. C.E., was too well known during his lifetime to require identification by an extensive biography. Although his professional interests were world-wide, he specialized in problems of hydraulics, in the study of earthquakes and their effect on structures, and in problems of fire prevention. He was consulted on water supply projects from the Atlantic to the Pacific; he advised the Chinese Government on the control of floods on the Yellow River, and the Italian Government on the control of floods on the Po River.

He graduated from the Massachusetts Institute of Technology with the class of 1876 and subsequently was awarded the honorary degree of doctor of science by Brown University in 1904, by Tufts College in 1905, by the University of Pennsylvania in 1927, and by Yale University in 1931. He was also awarded two degrees from foreign universities: Doktor Ingenieur, Ehrenhalber, der Sachsiche Technischen Hochschule, Dresden, Germany; and Ehrenbürger der Technischen Hochschule, Karlsruhe.

In 1886 he became affiliated with the Associated Factory Mutual Fire Insurance Companies, in Providence, R.I., a connection he maintained for the rest of his life. In 1896 he was elected president of a group of Providence fire insurance companies. By improving mill construction and fire-prevention equipment he not only reduced the cost of mill insurance for 6,000 leading factories, but increased the amount of insurance held in these companies from about 65 million to nearly three billion dollars.

His contributions to the engineering profession were numberless. His generosity made possible the study of European hydraulic laboratory practice by young engineers, familiarly known as Freeman Scholars. In 1922 he served as President of the Society and in 1930 was made an Honorary Member. He died suddenly on October 6, 1932, after a remarkably full and successful professional life.

D. J. KERR, M. Am. Soc. C.E., a native of Scotland, was graduated from the University of Glasgow in 1904. Immediately thereafter he came to the United States, where he was employed for the next four years in the Maintenance Engineering Department of the Pennsylvania Railroad. In 1908 he worked for the Chicago, Milwaukee and Puget Sound Railroad on locating and reconnaissance work in the vicinity of Seattle and Spokane. Later he was at The Dalles, Ore., on the construction of the Oregon Trunk Railway. From 1913 to the present time he has been with the Great Northern Railway Company successively as Office Engineer, Chief Engineer of corporation during Federal control, and assistant to the vice-president in charge of operation. Also, since 1927 he has been president of the Cottonwood Coal and Somers Lumber companies, subsidiaries of the Great Northern Railway Company.

WALTER BOWEN SAUNDERS, M. Am. Soc. C.E., has specialized in hydraulic developments, both in the United States and in South America. His more important preliminary surveys and reports have been made on the South Fork of the American River in California, the Great Falls Development of the Tennessee Power Company, the Cannon Falls Dam, in Minnesota, and on hydro-electric possibilities in north-central Chile. His important construction projects include the Blue Earth Dam, in Minnesota, the Coon Rapids Dam on the Mississippi River, near Minneapolis, and La Ola Pipe Line in Chile. At present he is employed by the Andes Copper Mining Company in Chile as its Hydraulic Engineer, and he is also in charge of the operations of the Potrerillos Railway, a subsidiary of this company.

C. MAXWELL STANLEY, Jun. Am. Soc. C.E., was graduated from the University of Iowa in 1926, with the degree of bachelor of sci-

ence in general engineering. Following his graduation, he accepted a position with the Byllesby Engineering and Management Corporation, where he remained for a year. From May 1927 to June 1928 he was employed on design and construction work at the Hydraulic Laboratory of the University of Iowa and at the same time did graduate work at the university, receiving the master's degree in hydraulic engineering in 1930. From June 1928 to February 1932, he was with the Management and Engineering Corporation on the design, construction, and operation of hydro-electric and water-works projects, and the design of Diesel engines, power plants, and railway terminals. From February 1932 to the present he has been a partner in the firm of Young and Stanley, Inc., consulting engineers of Muscatine, Iowa.

BERNARD L. WEINER, Assoc. M. Am. Soc. C.E., a native of Lithuania, came to the United States in his childhood. In 1922 he was graduated from the College of Engineering of New York University. He was then employed for three years on design and construction work for various New York City engineering departments. In October 1925 he joined the staff of the Westchester County Park Commission as a structural draftsman and soon afterward was promoted to the position of designer in charge of a squad. Always interested in structural research and mathematical analysis, he found an opportunity to put this enthusiasm to practical use in the Design Division of the Commission, where he remained until April 1932.

Advantages of Membership in Student Chapters of the Society

By T. L. HODGES, JUN. AM. SOC. C.E.
ASHEVILLE, N.C.

TO KEEP the average young man of college age at work at a specific task until this task has been thoroughly completed, is indeed a difficult problem. In this era when there exist so many attractions which seem to be lurking in the path to a college degree, distracting the attention of the student from his real aim, this problem becomes one of the gravest concern to educators, parents, business men, and engineers.

The Student Chapters of the Society have in their grasp the power to impress firmly and vividly upon the minds of the civil engineering students the lesson of tenacity in the accomplishment of a job. These Chapters form the link which connects the theory of the classroom with the hard, cold reality of engineering facts and construction. The Chapters keep before the eyes of the members the achievements of practical men and the difficulties and problems which they have met, grappled with, and overcome It is therefore to the best interest of the civil engineering profession that these Chapters be strengthened, that they be multiplied, that they be encouraged to strive for a more rounded and a more thorough knowledge of the profession from which they spring.

ENGINEERING OF MEN

Today there is one great void in the curriculum of our engineering schools which can be filled by but one "filler." The void is a course in the curriculum of the engineering student in the "engineering of men." There is no other profession on the face of the earth which so often demands that one man accomplish a huge undertaking merely by the instructing of other men in such a way that they will understand and respond willingly and readily, as does the engineering profession.

It is evident that the engineering of materials and methods of construction can be learned from textbooks or from personal instruction. This kind of engineering demands concentrated study for four years. Often the study of the engineering of materials blinds the student to the other factors of an education, and makes him an even poorer engineer of men and affairs than he would have been without that education. It is during his college days that the "filler" should be applied.

The natural outlet for the things that are in the heart and mind of the engineering student is an organization which stands for the principles upon which the student is to build the remainder of his active life. The Student Chapters of the Society provide this outlet. It is at the meetings of these Chapters that the student may mingle with other students who have identical aspirations. It is there that he can make known his opinions, can discuss matters of a technical nature which are of much interest to him. Here an atmosphere of common fellowship and unity in the following of one profession prevails. These societies tend to broaden the cultural life of the student, teach him to get along well with his co-workers, and develop in him a certain amount of managerial ability.

Obviously colleges cannot, and apparently do not, instruct a student in the "engineering of men." The Student Chapters of the Society can, if conducted in a correct way, fill this void. Men who hold offices in the Society have an excellent opportunity to develop in some measure a managerial or executive ability. Committees afford possibilities for others to develop this same trait. It is only by being among men who have the same interests, the same respect for the profession, and the same problems that this knowledge of human nature, so essential to the civil engineer, can be acquired.

BUILDS RESPECT FOR THE PROFESSION

The Student Chapters of the Society develop a loyalty to, and a new respect for, the profession of civil engineering. It is in the Society that the student first realizes the vastness of the field before him, the possibilities open to him, and the prestige which has been built for the profession through years of accomplishment and toil on the part of members of the Society who have preceded him. He sees his place in the solving of the problem of directing his own efforts and the efforts of others so that human existence may be happier, and so that the comforts and necessities of life may be more evenly distributed among his fellow men.

Most of the Student Chapters of the Society indulge to some extent in recreational activities in the form of banquets, smokers, and other gatherings, where there is a camaraderie between members which often develops into enduring friendships. Engineering work often causes men to be thrown together under adverse circumstances and with unpleasant living conditions. The hardships of excessive heat and cold, and the physical strain of long hours in the field and in the drafting room are factors which try men's patience. The men who stand this life and who are best adapted for it are the men who have had experience in dealing with other men. In their college days they learned the knack of working with their fellow students, having the accomplishment of a mutual task as their goal.

ETHICAL RELATIONSHIPS LEARNED

The Society has a code of ethics to which its members are required to adhere closely. The word "ethics" is seldom thought of by the layman in connection with the engineer or an engineering job. However, it means as much to the engineering profession as it does to the professions of law or medicine. The conduct of an engineer in his dealings with his clients, his competitors, and his fellow engineers has its effect on the name and reputation of the Society. It is in the Student Chapters that the civil engineering student first learns of the ethics of the profession. A knowledge of it is made available to the embryo engineer in talks by prominent men of the profession, in the literature of the Society, and through association with his college mates.

There are material advantages in membership in a Student Chapter of the Society which the student may readily recognize, provided he has serious intentions of following the civil engineering profession. Membership as a Junior is made particularly easy to the college graduate who has been a member in good standing in his Student Chapter. Membership in the Society is respected by all who have any knowledge of the profession. Without a degree from an accepted technical institution and without membership in a Student Chapter, many years of actual experience would be necessary for a man to gain admittance to this highly esteemed Society.

Student Chapters of the Society are rapidly increasing in strength as knowledge of the basic principles upon which they are founded is spread. There is one outstanding characteristic of this heterogeneous mixture of nationalities which is called the American people, and that characteristic is a universal and increasing belief in the elusive thing called education. With the attainment of this education comes the desire for an outlet for the application of the knowledge that has been gained. The civil engineering student may have any number of opportunities to get his education, but without some such technical organization as a Student Chapter of the Society, he is deprived of the chance of free discussion with

his co-workers, of learning of many of the achievements of the men in his chosen profession, and of the pleasure and profit of fellowship with men with whom he will later work on problems of far greater magnitude than we can now realize.

Code Making

VERY SURELY, although very slowly and with meager information, the significance of an engineers' code is becoming a topic of discussion among engineers. Certain facts, being fundamental, although previously stated, can hardly be repeated too frequently. They are the foundations upon which a code structure must rest and the elements which must govern its shape and general purpose. The order in which these facts are listed here has no significance.

1. Codes must be written by employers.
2. Each code must contain the provisions that the employers functioning under this code will permit collective bargaining, will not employ child labor, will not require their employees to work more than so many hours a week, and will not pay any of their employees less than so much an hour.
3. Each code may set up any set of rules for the control of the business of these employers which, being called "fair practices," must be binding upon those employers in the conduct of their business. An authority to enforce these rules upon violating employers is established, all subject to approval by the Administration.
4. No code may directly or indirectly impose restraint or other limiting conditions upon any one other than the employer who functions in the field for which the code is written.
5. Employees, individually or collectively, have nothing to do with any code because they are not the owners of the business, nor do they accept financial responsibility in the conduct of the business. However, each industrial Authority includes, as nonvoting members, three representatives of the Administration: one representative of labor, one of the consumer, and one of industry in general.

Father of Scientific Management Honored

LAST MONTH, on December 7, 1933, the fiftieth anniversary of the graduation of Frederick W. Taylor from Stevens Institute of Technology was celebrated. He was the original advocate of the principles of scientific management underlying modern, large-scale industrial production. The celebration was a part of the annual meeting of the American Society of Mechanical Engineers and the Taylor Society and was participated in by representatives of 87 colleges and universities and delegates from many national scientific and engineering organizations, among them the Society.

Born in 1856, Mr. Taylor prepared at an early age at Exeter for entrance to Harvard. Although he passed the entrance examination, the concentrated study so affected his eyesight that he entered a machine shop instead and at the Midvale Steel Company soon became machine-shop foreman. Here he became convinced that mechanical engineering was his life work and made arrangements to take the course at Stevens Institute without giving up his work at Midvale. In less than four years he had completed his course off the campus and graduated with the class of 1883.

At Midvale he began the task of gathering together the great mass of traditional knowledge which in the past had been in the minds of the workmen, and in their physical skill and knack. This he tabulated, reduced to laws and rules, and in some cases to mathematical formulas. From study and time observations he was enabled to eliminate "soldiering" on the part of those performing manual work.

During his study of lathe-cutting operations in the machine shop, he discovered high-speed steel—a discovery that has revolutionized machine-shop practice. He was able to set piece-work rates accurately; he established planned control in shop management; and set standards of workmanship and accomplishment. He applied the scientific method to every project with which he was associated, and carried it even into his avocations. He designed a special golf putter, and used a unique tennis racket. He devised methods of growing grass on putting greens, of growing flowers and vegetables, and of transporting shrubbery.

During his career he wrote many books, among which *Concrete, Plain and Reinforced* and *Concrete Costs*, written in collaboration with Sanford E. Thompson, M. Am. Soc. C.E., are perhaps the best known to civil engineers. He is most famous as the father of scientific management and elimination of waste motion in both men and machines. He died in 1915 on his fifty-ninth birthday.

Reminiscences of Pioneer Days

An interesting personal story is contained in a letter written by Lincoln Bush, Hon. M. Am. Soc. C.E., to A. J. Hammond, President of the Society. By permission of both Mr. Hammond and Mr. Bush the letter is published here in full.

DEAR MR. HAMMOND: We recently received the 1933 TRANSACTIONS of the Society and have read your presidential address, "A Century of Civil Engineering in the United States." It thrilled us. Mrs. Bush and I date back to the 1860's and are of pioneer blood. That which we have lived and learned enables us to feel, appreciate, and understand better what you have said about a "Century of Progress" dating back to 1833.

In 1830 my mother, at the age of five, migrated with her parents from Ohio to Will County, Illinois, and rode horseback behind her mother, fording and swimming the Maumee and Kankakee rivers on the way. There was a bridge at that time across the Maumee River at Fort Wayne but the riders, with another family from Ohio, followed the short-cut trail, while my grandfather traveled by ox-team and wagon by way of Fort Wayne.

During the War of 1812—in August of that year—the Indians attacked and burned Fort Dearborn in Chicago, and 60 white people, including men, women, children, and soldiers, were killed or massacred without quarter along the lake front. The bodies of the slain remained unburied on the battlefield for four years, except for those the wild animals disposed of. In 1832 the second Black Hawk War occurred, and my mother, her mother, and other settlers fled for protection and refuge to the rebuilt Fort Dearborn. For several days the fort was seriously threatened by Indians, but relief arrived in time to avert a recurrence of the massacre of 1812.

My father migrated from Vermont to Illinois in 1832, when he became of age. He traveled by the most expeditious route of the day, arriving in Chicago in 30 days, via Lake Champlain, the Champlain Canal, the Erie Canal (from Albany to Buffalo, with its 4-ft depth of water that you have described), a lake vessel from Buffalo to Detroit, and horseback from Detroit to Chicago. When he started West, his father gave him a muzzle-loading rifle, and his mother gave him a silk handkerchief, all the property he ever inherited, except a large measure of the heritages that characterized our pioneers.

In October 1825 as a water pageant swung from Lake Erie into the new Erie Canal, there began the successive and impressive firing of cannon which had been previously stationed at points from Buffalo to Albany and down the Hudson River to New York. In three hours the acknowledgment of the "wedding of the waters of Lake Erie with the Atlantic" came back. Practical telegraphy was unknown until 1844.

Thus our Hudson River frontier was pushed west 1,500 miles from the banks of the Hudson to the Mississippi Valley, and New York was made secure as the dominating seaport of our country.

LINCOLN BUSH, Hon. M. Am. Soc. C.E.
Consulting Engineer

East Orange, N.J.
November 15, 1933

Appointment of Society Representative

GEORGE GIBBS, M. Am. Soc. C.E., represented the Society at the fiftieth anniversary of the graduation of Frederick Winslow Taylor from Stevens Institute of Technology, held on December 7.

A Preview of Proceedings

A new use for the Williot diagram has been derived and is being presented in the January number of PROCEEDINGS. *Hydraulic engineers will find special interest in the article presenting a new set of tables for sharp crested, suppressed weirs. Also in this issue, a paper on the method of installing new bearings in the Panama Canal lock gates, some of which weigh nearly 800 tons, will form another valuable contribution to engineering literature. One paper announced last month for appearance in the December number of* PROCEEDINGS *was necessarily delayed until January. That is the one entitled "An Approach to Determinate Stream Flow," by Merrill Bernard, M. Am. Soc. C.E.*

WILLIOT EQUATIONS FOR STATICALLY INDETERMINATE STRUCTURES

IN HIS PAPER, Charles A. Ellis, M. Am. Soc. C.E., describes a recently discovered inherent quality in the Williot diagram, and shows particularly how this discovery may be used in connection with the well-known method of expressing end moments in terms of angular displacements for the solution of a certain structure, many times statically indeterminate. Heretofore the Williot diagram has served three principal purposes, but only after the primary stresses and corresponding strains have been determined. It has been used for finding simultaneously the deflections of all the joints of a truss; it has been used with Maxwell's theorem of reciprocal displacements for solving the reactions of swing spans, two-hinged arches, and similar statically indeterminate structures; and in secondary stress computations for a statically determinate structure, it has been employed to supply the angular rotations of members.

This paper shows how the Williot diagram may serve a very useful purpose even before the stresses and strains are known or can be determined. The method is illustrated by the outline of a solution, showing the best method of taking the preliminary steps for approximating a tentative design from which the cross-sectional areas and moments of inertia may be computed. The Williot diagram may then be sketched and equations in terms of strains developed from it. These equations taken in connection with the end moment equations which may be set up are sufficient for finding the stress distribution. For example, in any distorted structure with fixed joints the chords participate with the webs in resisting shear. If a structure contains abnormally stiff chords, the usual assumption that the webs resist all the shear may prove to be very erroneous.

The combination of these two methods will solve problems of this character, and it can be made to serve in other instances where the methods of work and of least work are either cumbersome or impotent. Discussion of this paper is expected to validate the virtues of the method or to throw light on its limitations.

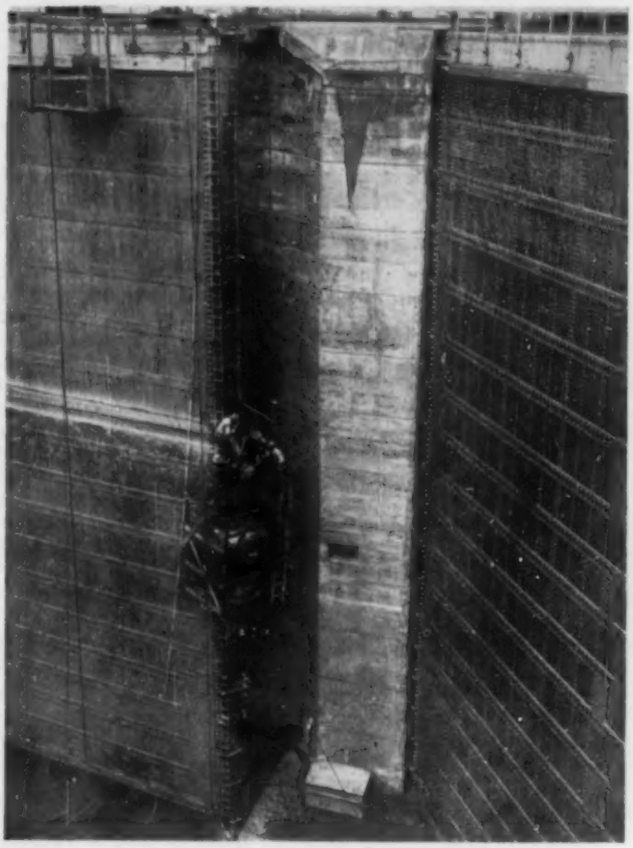
DISCHARGE FORMULAS AND TABLES FOR SHARP-CRESTED SUPPRESSED WEIRS

THE PAPER by C. G. Cline, of Niagara Falls, Ontario, Canada, is based on a former paper by E. W. Schoder and the late K. B. Turner, Members Am. Soc. C.E., entitled "Precise Weir Measurements" and published in Volume 93 (1929) of TRANSACTIONS. In a sense it is an analysis of the experimental data presented in the previous paper. Projecting his own analysis further, Mr. Cline introduces for discussion an empirical derivation of a new weir formula derived with great precision and considerable accuracy. The application of the new formula offered by him is facilitated by the use of specially prepared tables. In this paper, he has included such tables and has presented examples of them sufficient for readers to form a judgment as to their possible utility. A complete set has been filed for reference with the original manuscript in the Engineering Societies Library. Separate sets, comprising all the 15 tables, are being printed by the Society in numbers sufficient to place them on sale at a nominal price of 50 cents a set.

RENEWAL OF PANAMA CANAL MITER-GATE BEARINGS

AFTER twenty years of operation, wear on the vertical bearing surfaces of the Panama Canal miter gates indicated that a system of progressive replacement of these bearings was advisable. A paper by Clinton Morse, Jun. Am. Soc. C.E., describes the equipment developed for the eventual renewal of the bearings on all gates.

In order to make the quoin bearings accessible, it is necessary to raise the leaves (the largest of which are 82 ft high and have an estimated gross weight of 790 tons) clear of the pintles and move them from the wall. Twelve hydraulic jacks, connected to needle beams under the leaf, raise the leaf sufficiently to clear the pintle and to allow roller trains and tracks to be placed under the leaf. This paper deals in particular with the overhauling of the Miraflores Locks and features the improvement in equipment and method made possible by the experience gained in raising 22 gates during three overhaul periods.



OVERHAULING MITER GATES ON THE PANAMA CANAL

News of Local Sections

ARIZONA SECTION

At the annual fall meeting of the Arizona Section, held in Phoenix on November 18, officers for 1934 were elected as follows: Earle V. Miller, President; E. S. Borgquist and J. A. Fraps, Vice-Presidents; and Clyde Myers, Secretary-Treasurer.

CENTRAL OHIO SECTION

On November 15 the annual meeting of the Central Ohio Section was held at Columbus. During that session the following officers were elected for the coming year: B. F. Hatch, President; W. H.

Critser, First Vice-President; F. E. Swineford, Second Vice-President; and P. M. Holmes, Secretary-Treasurer.

DAYTON SECTION

The regular monthly luncheon meeting of the Dayton Section was held at the Engineers Club on November 20. At that time Nelson J. Bell, chairman of the Engineers' Code Committee of the Section, presented an outline of a proposed code and also reported on a joint meeting of all the Local Sections in Ohio, held in Columbus on November 13 for the purpose of classifying engineers' salaries. The attendance at the luncheon meeting was 25.

GEORGIA SECTION

A meeting of the Georgia Section was held in Atlanta on November 6. Various business matters, including the reading of the nominating committee's report, occupied part of the session. The scheduled speaker, C. E. Weaver, was unable to be present, so S. R. Young, Chief Engineer of the Atlanta and West Point Railroad Company, led an enthusiastic discussion on the subject of railroads.

IOWA SECTION

There were 75 members and guests present at the annual meeting of the Iowa Section, which was held in Des Moines on November 16. The principal speaker of the afternoon session was R. A. Moyer, Assistant Professor of Civil Engineering at Iowa State College, who gave an address on the subject, "Skidding Characteristics of Various Road Surfaces and Conditions of Road Surfaces." The organization and work of the Committee to Study and Report Salary and Wage Information for the Engineers' Code were then described. The annual election of officers, held at this time, resulted as follows: T. R. Agg, President; C. C. Williams, Vice-President; and R. B. Kittredge, Secretary-Treasurer. In the evening J. S. Dodds, Associate Professor of Civil Engineering at Iowa State College, gave a talk on the subject, "The U. S. Coast and Geodetic Survey Work-Relief Project in Iowa."

ITHACA SECTION

A dinner meeting of the Ithaca Section was held at the Langwell Hotel in Elmira, N.Y., on November 16. The guest speaker for the occasion was George E. Shafer, Engineer of Tests for the Armco Culvert Manufacturers' Association, of Middletown, Ohio, who chose for his topic, "Drainage and Drainage Products Improved by Research." There were 22 members and guests present.

KANSAS CITY SECTION

There were 25 members present at a dinner meeting of the Kansas City Section, which was held at the Hotel Baltimore in Kansas City, Mo., on November 22. The session was addressed by A. C. Everham, of the Raymond Concrete Pile Company, on the subject of the application of the NRA codes to professional engineers and on the effect of the Public Works Administration on the construction industry. The main speaker of the evening was Matthew S. Murray, Director of Public Works of Kansas City, who spoke on relief employment and the construction of the new municipal auditorium. This address aroused considerable interest and provoked discussion from the floor.

LOS ANGELES SECTION

On the afternoon of June 17 the Los Angeles Section held its annual field day at the Oakmont Country Club in Glendale. Field and track events were followed by a steak supper and the presentation of a skit satirizing the engineering profession in general. This event was attended by 150 members and guests. At the meeting held on August 16 at the University Club, Carlton S. Proctor addressed 107 members and guests on the proposed code for engineers. On September 13, about 150 members and guests gathered at the University Club to discuss the administration's public works program. The meeting on October 11, which was also held at the University Club, was attended by 120 engineers. The speakers for the occasion were members of the Board of Economic Survey of the Los Angeles Harbor. "Ladies' Night," observed at the Breakfast Club on November 8, proved popular. A total of 270 enjoyed the entertainment, music, games, and dancing. At the annual meeting, held on December 13, the newly elected officers of the Section were installed. The list of these is as follows: Merrill Butler, President; Kenneth Q. Volk and Harold L. Doolittle, Vice-Presidents; and John C. Albers, Treasurer. The membership of the Section was reported as 498 by A. L. Gram, who will continue as secretary.

MARYLAND SECTION

On the evening of October 26, Abel Wolman, Chief Engineer of the Maryland State Department of Health, addressed a meeting of the Maryland Section held at the Engineers Club in Baltimore. He gave an able discussion of the activities of the Public Works Administration, dwelling particularly on the problem of getting a program of work under way.

METROPOLITAN SECTION

There were approximately 150 in attendance at the regular meeting of the Metropolitan Section, held in the Engineering Societies Auditorium, in New York, on December 20. The guest speaker was Capt. Hans Kramer, who outlined the general work of the U. S. Corps of Engineers on flood control on the Mississippi and gave an intimate picture of the activities of the U. S. Waterways Experiment Station at Vicksburg, Miss. The showing of slides and motion pictures enhanced the presentation. Those covering the operation of one of the large cut-offs were particularly interesting. At the conclusion of the meeting refreshments were served.

NORTHEASTERN SECTION

A buffet supper preceded the regular November meeting of the Northeastern Section, held in Boston on November 8. Several business matters were attended to, including the election of a nominating committee. Two interesting talks were given. The first speaker was Harrison P. Eddy, Jr., of the firm of Metcalf and Eddy, whose subject was "What Engineers Can Do to Help the NRA." The second speaker was Charles R. Gow, Massachusetts State Engineer for the Public Works Administration, who discussed the topic, "Work Under the NRA." Interest in these two papers was manifested by enthusiastic discussion from the members.

PHILADELPHIA SECTION

On November 15 a dinner meeting of the Philadelphia Section was held, with 76 present at the dinner and 122 at the meeting that followed it. Two illustrated addresses were presented. W. H. Ellis, Assistant Erection Engineer of the Phoenix Bridge Company, described the construction of the Jersey Meadows Viaduct, the recently completed elevated highway from Elizabeth, N.J., to the approach to the Holland Tunnel in Jersey City. The Golden Gate Bridge, now under construction across the entrance to San Francisco Bay, was the subject of a talk given by E. F. Ball, Assistant Chief Engineer of the McClintic-Marshall Corporation.

PORTLAND (ORE.) SECTION

A joint meeting of the Portland Section and the Professional Engineers of Oregon was held at the University Club on November 21, with 50 present. After routine business matters had been attended to, the speaker of the evening, Claude I. Grimm, Chief Civil Engineer of the Pacific Division of the U. S. Army Engineers, spoke on the subject, "Engineering Aspects of the Bonneville Dam." Other talks on this construction project were given by L. F. Harza, who has recently been retained as a consulting engineer on the project; D. C. Henny, who has likewise been engaged as a consulting engineer on the work; and Ira Williams, a geologist, who described the formations at the site. The meeting was then turned over to general discussion.

Student Chapter News

COOPER UNION STUDENT CHAPTER

A meeting of the Cooper Union Student Chapter was held on November 28, with 60 members in attendance. The feature of the occasion was an illustrated address by William H. Meyer, Jr., of the Fairchild Aerial Surveys, Inc., who gave an interesting résumé of the history and uses of the aerial survey and its importance in engineering work.

ITEMS OF INTEREST

Engineering Events in Brief

CIVIL ENGINEERING for February

WESTERN TRAVELERS in China accept the thousands of graceful and venerable stone bridges as a part of the landscape through which they pass. An exceedingly interesting article, both historical and descriptive, by H. Fugl-Meyer, of Copenhagen, traces the development of Chinese bridge building from 1000 B.C. and describes the construction of many types: pontoon, wooden, stone-slab, truss, cantilever, chain and bamboo-rope suspension, and stone arch. Some of these have members so large and heavy that it is a marvel how they were erected. This fascinating article is being prepared for the February issue.

As an example of recreational highway construction, the parkways in Westchester County, New York, are an outstanding development. Such features as a shielded strip of land on each side of the paved motorway, which excludes privately owned, abutting property from direct contact with the roadway; the elimination of grade crossings, both railroad and highway; infrequent occurrence of access and exit roadways, make the motor expressways in this county a delight to all who travel them. A brief article by Jay Downer, M. Am. Soc. C.E., gives the broad theory of the design of the system and brings out its economic worth in enhancing the value of the taxable property of the county during the 11 years that the Westchester County Park Commission has been in existence.

At Lehigh University, H. G. Payrow, M. Am. Soc. C.E., has recently completed a series of tests on the durability and soundness of materials for trickling filters. Both the sodium sulfate and the controlled alternate freezing and thawing test were conducted. Although Professor Payrow concludes that the sodium sulfate test is adequate, if the technique is standardized, nevertheless he finds the freezing and thawing test not only more nearly conclusive and closer to actual conditions, but also more convenient and economical to use. Methods and results are both given in his article, to appear in the February issue.

Another enlightening experiment on the movement of bed materials in rivers has been concluded at the U. S. Waterways Experiment Station at Vicksburg, Miss. The tests verify the results of experiments conducted in European laboratories to the effect that more bed material is conducted into a diversion channel in proportion to the amount of water carried by it than is conducted by the main channel. In an article to appear in the February issue, H. D. Vogel, Assoc. M. Am. Soc. C.E., gives the most important conclusions to be drawn from the experiments on the movement of the bed load in a forked flume.

In the November 1933 issue, R. P. Pennoyer, Assoc. M. Am. Soc. C.E., outlined the essential steps required in calculating the loads to be supported by steel sheet-piling bulkheads and in selecting the pile section required. In a second article, to appear in the February issue, he presents the design of the details of these bulkheads, such as tie rods, wales, anchorage, fender timbers, and mooring posts, together with construction methods which will produce a rugged, simple, and economical bulkhead.

Other articles are in preparation and will be included as space permits. Abstracts of the papers read before the Annual Meeting will appear in the March issue of CIVIL ENGINEERING.

High-Level Railroad Bridge in Sioux City, Iowa

By C. C. EVERHART, JUN. AM. SOC. C.E.
MOVILLE, IOWA

ON the Page of Special Interest at the beginning of this issue appears a view in pen and ink of the High-Level Bridge of the Chicago, St. Paul, Minneapolis and Omaha Railroad near Sioux City, Iowa, drawn by R. E. Beard, of Moville, Iowa. Although the settlement of Sioux City began in 1850 and a railroad was placed in operation along the Iowa shore of the Missouri River in 1868, it was not until 1888 that this interesting bridge was opened to rail traffic. It stands on historical ground. The Lewis and Clark expedition crossed the river at this site in 1804, and nearby they buried the body of Sergeant G. C. Floyd, a member of the expedition who died there. To the river which has its mouth a few hundred feet upstream from the bridge site, they gave the name Floyd in his honor. In 1900 a giant stone shaft was dedicated to his memory. The grave of the famous Omaha chieftain, Blackbird, is downstream a few miles.

In 1876 the present site was authorized by Congress for bridge purposes, but before plans were perfected the great flood of 1881 occurred, the greatest ever known or recorded in this section of the valley. It reached a peak of 360,000 cu ft per sec on April 23, 1881, and swept away whole villages, causing great property damage, physical suffering, and loss of life. Ice jams formed, and at one stage of the flood the whole river from Yankton to Vermilion, S.D., was gorged with huge ice blocks, some of them 100 ft square, piled to a height of 30 ft above the water level.

On the Iowa shore, the approach to the bridge is through a cut in Sawyers Bluff, having a maximum depth of 85 ft near the bridge. The east approach is 1.65 miles long, and the fill contains 167,000 cu yd of material. The Nebraska approach, 1.92 miles long, was originally mostly trestle but now has been replaced with earth fill.

FOUNDATIONS REQUIRE AIR PRESSURE

An open sheeted cofferdam was constructed for the Iowa shore pier where the general ground level is at elevation 686, St. Louis datum. The excavation was carried to elevation 664, at which depth 30-ft piles were driven and cut off at elevation 665. On the piles a double row of oak timbers 12 by 18 in. was laid flat. On this grillage 778 cu yd of Morton granite and Mankato limestone was laid to form the pier. Sand from this excavation was used for the masonry.

At the Nebraska (west) land pier, located on the wide, flat flood plain of the river, a pneumatic caisson was sunk 58 ft below standard low-water level (which was at elevation 667.7) to a final bearing on blue clay. Concrete was used to fill the caisson chamber, which was 23 by 50 by 15 ft deep. On top of the concrete a granite and stone pier was built up to the bridge-seat level at elevation 724.

Piers 2, 3, and 4, located in the river channel, deserve special mention for several reasons. They were placed in a stream which scours deeply, is subject to heavy ice gorges and jams, and frequently carries heavy floating debris. Soil borings disclosed chalk rock at elevation 500, on which there lay a bed of pre-alluvial gravel about 77 ft thick. The caissons for the river piers were sealed on the gravel. A progress log of pier No. 2 may be of interest for comparing the old work with the new. On October 19, 1887, concreting the caisson was started; on October 21 sinking began; the final depth, at elevation 579.47, was reached by January 12, 1888. During the next 12 days the caisson was sealed, and by June 23, 1888, the masonry pier had been completed to bridge-seat level. The load is given as 8,624 tons. The river caissons were rectangular in plan, 28 by 60 ft in section, with a working chamber 18 ft deep, and were constructed of pine, oak, and steel plates provided with a steel cutting edge. Above the working chamber the concrete-filled crib extended another 29 ft. On it the stone section of the piers was built. The tops of the piers are approximately 9 ft wide by 36 ft long. An examination of these piers shows that they have graceful lines, fine proportions, symmetry, good subdivision of units, a monumental but not depressing character, and in general can be said to obey the cardinal

principles of art and architecture as applied to fine masonry design. The five piers contain 14,171 cu yd of masonry.

Cooper's E-30 loading was used in designing the superstructure of the bridge. The four main spans are each 400-ft Whipple trusses, with a depth of 50 ft and a center-to-center spacing of trusses of 22 ft. At the Iowa (east) end of the bridge there is a plate girder span 61 ft 6 in. long. The web of this girder is the only wrought iron in the superstructure. The two river spans on the Iowa side are of imported Scotch steel. A comment in the records states that this steel was more uniform in quality than that in the other two spans of American steel but was not so perfect in workmanship as the American fabricated spans. Full-sized eye-bars were tested. Working stresses of 14,000 lb per sq in. were used in the design of the top chord and 13,000 lb per sq in. in that of the lower chord.

This bridge now carries about 20 passenger and freight trains per 24 hr. These trains move over the Chicago, St. Paul, Minneapolis, and Omaha Railroad and the Chicago, Burlington, and Quincy Railroad. The bridge steel was fabricated by the Union Bridge Company, and Emil Gerber acted as resident engineer. A young engineer, Ralph Modjeski, M. Am. Soc. C.E., then a Junior, was a shop inspector on this bridge steel. The bridge stands today as a tribute to the designers, the late G. S. Morison and E. L. Corthell, both of whom later served the Society as President.

On a recent examination of this bridge, I was deeply impressed by the fine condition of the steel, masonry, and dozens of other details which showed without question that this bridge had received the very finest care. The watchman, who "sand-hogged" in the original construction, mentioned that great care was exercised to prevent cinders, dirt, manure, and water from trains accumulating in the angles and pockets. Expansion joints are kept very clean, and little or no work has ever been done on the original ironwork. The bridge has been painted once each seven years. The ashlar-faced piers have been polished by the water, sand, and ice, and the fine colors in the granite stand out well near the water line. During this inspection I thought of the many fine men who created this work, nearly all of whom are gone. What could be a finer monument to them than this bridge, still serving society long after "its masters have passed on?"

Illustrations from CIVIL ENGINEERING

AUTHORS OF ARTICLES which appeared in Volume II of CIVIL ENGINEERING, that is, in the year 1932, should note that the halftone and line-cut blocks for the entire volume are to be destroyed on February 1, 1934. If authors or others are interested in any of the illustrations, the original cuts may be obtained prior to that date by making application for them to Headquarters. There will be no charge other than the cost of forwarding the cuts by express or parcel post.

Requests will be filled in order of receipt, except that first choice will be given to the authors of the articles in which the illustrations appear. Other cuts are also available, such as those used on the covers, on the pages of special interest, in the programs of Society Meetings, and in departmental items.

The cuts used in Volume I have already been destroyed. As was announced a year ago, it is not convenient to store cuts for more than a year.

Cuts from Volumes III and IV will be loaned to those making requests for them, following the practice instituted with the first appearance of CIVIL ENGINEERING. However, such cuts must be returned when the desired use has been served. Frequent requests have been received for the loan of cuts in the current issues. In fact, some have been used in several different places. It is understood, of course, that when a cut is used credit will be given to CIVIL ENGINEERING.

Testing Engineers Occupy New Headquarters

HEADQUARTERS of the American Society for Testing Materials has been moved from the Engineers' Club Building, 1315 Spruce Street, Philadelphia, to more adequate offices in the Atlantic Building, 260 South Broad Street, in the same city. The present offices have been occupied for the past 14 years.

The new rooms comprise about 2,600 sq ft on the fifth floor of the building, to be devoted to offices, reception room, members' lounge, and board room, and 850 sq ft on the fourth floor for storage of publications and use as a shipping and general work room. The increase in total floor area is some 40 per cent, but that in general office space is nearly 60 per cent.

A large and more attractive board room has been planned, and most important, an adequate reception room and members' lounge will be provided. Greatly improved facilities for meetings of administrative committees will be available. The new rooms are excellently suited to the needs of the present and those for some little time in the future. Friends of the American Society for Testing Materials are cordially invited to inspect the new headquarters. They are convenient to railroad stations, hotels, and clubs, being just a half block from the Engineers' Club.

NEWS OF ENGINEERS

From Correspondence and Society Files

W. H. BOSIER has resigned his connection with the Kansas City Bridge Company to accept a position with the Missouri Valley Bridge and Iron Company. He is general agent for the company's Southwest territory and has his headquarters in Dallas, Tex.

PERRY A. WELTY has been appointed engineer-examiner in the office of the Federal Emergency Administration of Public Works, in Fort Worth, Tex.

WILLIAM OEHRLE has been made Resident Engineer of Public Works Administration in Columbia, S.C.

GEORGE P. STOWITTS, civil and consulting engineer, has recently announced that PUSEY JONES will hereafter be associated with him in an engineering partnership in Cincinnati, Ohio, under the firm name of Stowitts and Jones.

T. B. LARKIN, a major in the Crops of Engineers of the U. S. Army, has recently been transferred from service as District Engineer in the U. S. Engineer Office in Vicksburg, Miss., to the position of District Engineer of the Fort Peck District, Glasgow, Mont.

EDWIN ROSE has joined the staff of the U. S. Bureau of Reclamation, in Denver, as a junior engineer.

ROGER D. BLACK has accepted a position with the Board of Transportation of the City of New York on the construction of the Independent Subway System.

JOSEPH H. O'BRIEN, formerly Vice-President of Gibbs and Hill, Inc., of New York, N.Y., has accepted a position in a similar capacity with the Petroleum Heat and Power Company of the same city.

CONRAD W. O'CONNELL has joined the staff of the Standard Oil Company of Venezuela. He is stationed in Caripito, Monagas, Venezuela.

THOMAS J. DURRETT JR., who was formerly an estimator for W. F. Jackson Company, Inc., of Atlanta, Ga., has now received an appointment as Field Supervisor for the Georgia Relief Administration, with offices in the same city.

ALBERT L. LANE has been transferred from Fort Logan, Colo., to the U. S. Engineer Office at Port Isabel, Tex., where he will be assistant to the District Engineer of the Galveston District.

STEPHEN A. ROAKE has accepted a position as Assistant Engineer for the State of California on the construction of the San Francisco–Oakland Bay Bridge. His headquarters will be in San Francisco.

JAMES M. MCQUEEN, JR., has accepted an engineering position in the Sanitary Division of Arlington County, Virginia. He was formerly connected with the U. S. Department of Agriculture.

GROVER C. BROWN, who was formerly Manager of Training for the Bethlehem Steel Company, of Bethlehem, Pa., has joined the staff of the American Iron and Steel Institute, of New York, N.Y.

A. STREIFF, in charge of the southwestern territory for the Ambursen Dam Company, Inc., with headquarters in San Antonio, Tex., has been elected a vice-president of that company.

LESLIE R. AMES, former State Highway Engineer of the State Highway and Public Works Commission of North Carolina, has formed a construction company with S. C. Webb, the firm to be known as Ames and Webb, Inc., of Raleigh, N.C.

A. LAWRIE KURTZ has accepted an appointment as engineer-examiner in the Federal State Engineer's Office, Public Works Administration, Madison, Wis.

BARTON M. JONES has resigned as head of the Engineering Department of Antioch College, at Yellow Springs, Ohio, to become Construction Engineer for the Tennessee Valley Authority on the Norris Dam Project. His headquarters will be in Knoxville, Tenn.

OREN REED has accepted a position as Camp Engineer for the Indiana Emergency Conservation Work Camp No. 2, located in Lincoln City, Ind.

WILLIAM G. SLOAN has recently been appointed State Highway Engineer of New Jersey, with headquarters in Trenton.

ARTHUR F. JOHNSON has resigned his position as junior cartographic engineer with the U. S. Coast and Geodetic Survey to accept an appointment as a junior engineer in the U. S. Bureau of Reclamation, with headquarters in Denver, Colo.

WILFRED M. HALL, an engineer of New York, N.Y., has received an appointment as Engineer in Charge of Construction of the General Joe Wheeler Dam on the Tennessee River, a project of the Tennessee Valley Authority.

JOEL M. JACOBSON, formerly an instructor in civil engineering at Armour Institute of Technology, has accepted a position as Aeronautical Engineer with the Kreider Reisner Aircraft Company, of Hagerstown, Md.

LEE H. HUNTLEY has been appointed construction superintendent of the General Joe Wheeler Dam by the Tennessee Valley Authority.

E. N. GUSTAFSON has taken a position as engineer-examiner with the Federal Emergency Administration of Public Works, in Fort Worth, Tex. He was previously County Highway Engineer for Matagorda County, Texas.

CARL L. BARKER is now an instructor in civil engineering at the University of Alabama.

EDWARD A. BYRNE has resigned as Chief Engineer of the New York City Department of Plant and Structures to accept a position in a similar capacity with the Triborough Bridge Authority, also in New York.

N. BALOFF, formerly a draftsman for the Continental Can Company, of San Francisco, Calif., has now accepted a connection with the U. S. Bureau of Public Roads, with headquarters in the same city.

L. BOYD MERCER has established a consulting engineering practice in Melbourne, Australia. He will specialize in the bulk handling of grain, elevator construction, and work with reinforced concrete.

FRANCIS L. BELL, formerly with the Common Brick Manufacturers' Association of America, with offices in Milwaukee, Wis., has now accepted a connection with the Illinois Brick Company, of the same city.

DONOVAN H. LEE has recently resigned as technical director for the Aston Construction Company, of London, England, to establish a consulting engineering practice of his own at 6 New Burlington Street, W.1, London.

C. I. GRIMM has been assigned by the U. S. Department of War to the position of Chief Engineer on the construction of the Bonneville Dam on the Columbia River. His headquarters are Portland, Ore.

WILBUR W. DAVIS has been promoted from the position of Assistant Chief Engineer for the City of Boston Transit Department to that of Chief Engineer in the same department.

WILLIAM C. E. BECKER has resigned from the firm of Taxi and Becker, consulting engineers, to become Chief Engineer of the Division of Bridges and Buildings in the Department of the President of the Board of Public Service, City of St. Louis.

W. C. STRECKER has been called to active duty in the Civilian Conservation Corps Camp No. 6, at Davenport, N.Y. Previously he was with the General Electric Company, of Schenectady, N.Y.

E. O. SWEETSER has been made acting head of the civil engineering department of Washington University, in St. Louis, for the current academic year, to succeed J. L. VAN ORNUM who is on a leave of absence.

C. H. BIRDSEYE is now chief of the Division of Engraving and Printing, of the U. S. Geological Survey, with headquarters in Washington, D.C.

BERT R. MULLEN resigned as Government inspector on Missouri River work to become technical adviser to the ten soil-erosion camps that the Government maintains in the State of Missouri. He is located in Jefferson City.

A. T. PARSONS has accepted the position of manager of the Bay Pest Control Company, of San Mateo, Calif.

Changes in Membership Grades

Additions, Transfers, Reinstatements, Deaths, and Resignations

From November 10 to December 9, 1933, Inclusive

ADDITIONS TO MEMBERSHIP

ASHFORD, OLIVER JOHN (Jun. '33), 2427 Harvard, North, Seattle, Wash.

ASK, REYNOLD EVERETT (Jun. '33), 5318 Nebraska Ave., Washington, D.C.

ASTON, JAMES WILLIAM (Jun. '33), 5901 Velasco, Dallas, Tex.

AVERY, WILLIAM MURDOCH (Jun. '33), 1453 Foster Ave., Chicago, Ill.

BARNUM, VINCENT DUDLEY (Jun. '33), 528 Highland Ave., Aliquippa, Pa.

BEARD, EARL GILMAN, JR. (Jun. '33), 501 Cumberland Ave., Park Ridge, Ill.

BEEKMAN, HENRY ALEXANDER (Jun. '33), 244 East 32d St., New York, N.Y.

BELLAVIA, LOUIS JIACOMO (Jun. '33), 132 Seaview Ave., Dongan Hills, N.Y.

BLICKENSDERFER, ALFRED (Jun. '33), 4726 Glenshade Ave., Cincinnati, Ohio.

BONNETT, CHARLES ALFRED (Jun. '33), Care, State Highway Office, Troutdale, Ore.

BRODAHL, JACK ASBJORN AUME (Assoc. M. '33), Field Engr., Clinton Constr. Co., Los Angeles (Res., 144 Eastmont Ave., El Monte), Calif.

BROWN, ELLIS ROBERT (Jun. '33), 308 Union St., Ashland, Mass.

BRUDENELL, ROSS NYMAN (Jun. '33), Hydr. Laboratory, Univ. of Iowa, Iowa City, Iowa.

CANTRAL, WAYNE WIOT (Jun. '33), 3412 Davenport St., Omaha, Nebr.

CARROLL, JOHN THOMAS (Jun. '33), Engr. Asst., Dept. of Public Works, New York (Res., 78-34 Eighty-third St.), Glendale, N.Y.

CASEY, HUGH JOHN (M. '33), Care, Am. Military Attache, U. S. Embassy, Tiergarten St., 30, Berlin, Germany.

CLICKENER, CORWIN KING (Jun. '33), 19 Fulton Ave., Waukegan, Ill.

CLOSE, HERBERT SCHOCK (Jun. '33), 22 Netherwood Ave., Plainfield, N.J.

COMERFORD, WILLIAM PIERRE (Jun. '33), 255 Fort Washington Ave., New York, N.Y.

COPLIN, PHILIP LOUIS (Jun. '33), 123 South Girard Ave., Albuquerque, N.Mex.

CRAWFORD, EDGAR GRENFELLE (Jun. '33), 1059 South Pasadena Ave., Pasadena, Calif.

CROPPER, GEORGE BERTRAND (Jun. '33), Ocean City, Md.

DABB, ALBERT HENRY, JR. (Jun. '33), 26 West Curtis St., Linden, N.J.

DERRY, STEPHEN JOHN-ARTHUR (Jun. '33), Draftsman, State Dept. of Highways, 1200 Third St. (Res., 2401 Derry St.), Harrisburg, Pa.

DIGIACINTO, ALBERT GEORGE (Jun. '33), 124 Winthrop Ave., Elmsford, N.Y.

EBERLIN, WILLIAM GRAHAM (Jun. '33), 154 Madison Ave., Perth Amboy, N.J.

EDMONDSON, PAUL BAXTER (Jun. '33), Draftsman State Highway Dept. (Res., 1410 West 20th St.), Amarillo, Tex.

ESTRIN, FRED (Jun. '33), With E. T. Archer & Co. (Res., 6025 South Benton), Kansas City, Mo.

EVERNHAM, EARLE BARNETT (Jun. '33), 1210 Eleventh Ave., Neptune, N.J.

FAHRBERGER, LOUIS FRANK, JR. (Jun. '33), 5452 Byron St., Chicago, Ill.

FALLON, ROBERT FORSYTH (Jun. '33), 696 Auburn Ave., Buffalo, N. Y.

FAY, ALBERT JAMES (Jun. '33), Lieut. (j.g.), C.E.C., U.S.N., 530 Huger St., Charleston, S.C.

FLINT, JOHN BERNARD (Jun. '33), 34 East Virginia Ave., Phoenix, Ariz.

FOGARTY, FRANCIS WILLIAM LAWRENCE (Jun. '33), 298 Union Ave., West Haven, Conn.

GILBERT, GEORGE DOUGLAS (Jun. '33), Ingot, Calif.

GROTE, ROBERT WALLACE (Jun. '33), 90 South Emerson, Denver, Colo.

GUYN, THOMAS CORWIN (M. '33), Project Engr., U. S. Indian Irrig. Service, Fort Hall, Idaho.

HAINES, DONALD HUTCHINSON (Jun. '33), 533 Fourteenth Ave., North, Seattle, Wash.

HANKINS, LAWRENCE DONALD (Jun. '33), Box 386, Coeur d'Alene, Idaho.

HANSEN, RALPH CHRISTIAN (Jun. '33), 1817 Sixth Ave., West, Seattle, Wash.

HARRIS, ROBERT MICHAEL SYDNEY (Jun. '33), 624 Fort St., Boise, Idaho.

HEINRICH, CHARLES JOSEPH (Jun. '33), 1254 Thirty-ninth St., Brooklyn, N.Y.

HELDENFELS, FREDERICK WILLIAM, Jr. (Jun. '33), Beeville, Tex.

HELLMICH, WALTER FREDERICK (Jun. '33), 6473 Scanlan Ave., St. Louis, Mo.

HERMAN, MURRAY (Jun. '33), Eng. Asst., Grade 3, Dept. of Parks, Brooklyn (Res., 62 West 104th St., New York), N.Y.

HILL, JACOB ERNEST (Jun. '33), Care, U. S. Bureau of Reclamation, Almira, Wash.

HO, CHITTY (Assoc. M. '33), Hydr. Engr., The Dept. of Reconstr., Kiangsu Provincial Govt., Chinkiang, Kiangsu, China.

HOFFMAN, IRVING CHARLES (Jun. '33), Engr., Los Angeles County Regional Planning Comm., Los Angeles (Res., 1931 Midvale St., West Los Angeles), Calif.

HOOK, HOWARD ARTHUR (Assoc., '33), Associate Civ. Engr., U. S. Dept. of Commerce, Div. of Airways, Washington, D.C.

HOOPER, HUGH BRAXTON (M. '33), Engr., U. S. Engr. Office, Room 323 Customhouse, Nashville, Tenn.

HUGHES, LEATON LEWIS (Jun. '33), 4461 Olive St., St. Louis, Mo.

HUHS, ROY ELBERT (Jun. '33), Dunnigan, (Yolo County), Calif.

HUNNELL, CHARLES, Jr. (Assoc. M. '33), Asst. Dist. Engr., State Highway Comm. (Res., 2017 Fairground Ave.), Vincennes, Ind.

HUNT, THEODORE WILLIAM (Jun. '33), East Greenbush, N.Y.

HURLEY, JOHN PATRICK (M. '33), With U.S. Consular Service, American Consulate, Nassau, Bahama Islands.

HURST, RUSSEL FRANCIS, Jr. (Jun. '33), Engineers Club, 1317 Spruce St., Philadelphia, Pa.

HUSSEY, PIERCE LEAPSON (Jun. '33), 2502 Dana St., Berkeley, Calif.

IZATT, JOHN ORMOND (Jun. '33), with State Highway Department, Grace, Idaho.

JAKUBOWSKY, JOSEPH FELIX JOHN (Jun. '33), Civ. Engr., Fort Hamilton (Res., 1376 East 12th St.), Brooklyn, N.Y.

JENSEN, VERNON PETER (Assoc. M. '33), Asst. Prof., Dept. of Theoretical and Applied Mechanics, Iowa State Coll., Ames, Iowa.

JOBBS, JAMES GIBSON (Jun. '33), Asst. Engr., U. S. Waterways Experiment Station, Vicksburg, Miss.

JOHNSON, CHARLES JAMES (Jun. '33), 1214 North West 25th Ave., Portland, Ore.

JOSLYN, CHARLES SHEAFE (Assoc. M. '33), Civ. Engr., Marc Eidlitz & Son., Inc., 100 East 42d St. (Res., 106 Bedford St.), New York, N.Y.

KENNEY, MILTON TURNER (Jun. '33), Lowell, Ind.

KIMMEL, ALFRED STEPHEN (Jun. '33), 59 North Main St., Miamisburg, Ohio.

KING, JOHN CALLEN, Jr. (Jun. '33), Junior Engr., U. S. Reclamation Bureau, Dept. of Interior (Res., 1515 Washington St.), Denver, Colo.

KIRKPATRICK, GEORGE ALEXANDER (Jun. '33), Care, U. S. Bureau of Public Roads, Trail, Ore.

KNAP, HANS JØRGEN (Jun. '33), 5459 Claremont Ave., Oakland, Calif.

KOCH, ALBERT ARTHUR (Jun. '33), 724 North Holliston Ave., Pasadena, Calif.

KRACK, ROBERT CHARLES (Jun. '33), 4781 White Plains Rd., New York, N.Y.

KREISS, ROBERT FREDERICK (Jun. '33), 3804 Minnehaha Ave., Minneapolis, Minn.

KRUSE, MARVIN OTTO (Jun. '33), Hartley, Iowa.

LANGMAN, RICHARD SHERRARD (Jun. '33), 1811 Twelfth St., Rock Island, Ill.

LE MOYNE, CHARLES, Jr. (Jun. '33), Rodman, U. S. Reclamation Service, Box 1118, Boulder City, Nev.

LOHMANN, ALEXANDER WILLIAM (Jun. '33), 25-51 Ninety-seventh St., East Elmhurst, N.Y.

MCGAUGHEY, PAUL THOMAS (Jun. '33), 144 Mayland St., Germantown, Philadelphia, Pa.

MAHLER, LOUIS VICTOR (Jun. '33), 6451 Grays Ave., Philadelphia, Pa.

MAKLE, ALBERT LEONARD (Jun. '33), Hotel Hoover, Whittier, Calif.

MARKS, SIDNEY MELVIN (Jun. '33), 80 Seventy-first St., Brooklyn, N.Y.

MILES, WALTER FRANK (Jun. '33), Junior Engr., U. S. Bureau of Reclamation (Res., 1760 Pennsylvania St.), Denver, Colo.

MILLER, ROBERT SMITH (Jun. '33), 117 East Walnut St., Oxford, Ohio.

MONNING, JOHN CHESTER, Jr. (Jun. '33), Chairman, Met. Water Dist. of Southern California, Banning (Res., 118 South Manhattan Pl., Los Angeles), Calif.

MOUSEL, FREDERICK WILLIAM (Jun. '33), R. F. D. 3, Mansfield, Ill.

MURPHY, EDWARD EVRE (Jun. '33), 33 Parkdale Ave., Buffalo, N.Y.

MYERS, WILLIAM NELSON (Jun. '33), Arlington Ave., Relay, Md.

NEMMERS, ELMER JOHN (Jun. '33), 603 East 16th Ave., Denver, Colo.

NEWHALL, GEORGE NELSON (Jun. '33), N.I.R.A. Indians Camp, King City, Calif.

NOSER, JOE EDWARD (Jun. '33), Box 429, Pharr, Tex.

ONDRUS, THOMAS (Jun. '33), 2440 South Ridgeland Ave., Berwyn, Ill.

PALM, ALF RAYMOND (Jun. '33), 4237 North Irving Ave., Chicago, Ill.

PELTIER, EUGENE JOSEPH (Jun. '33), 1001 Osage, Manhattan, Kans.

PFAFF, LLOYD ALBERT (Jun. '33), New Lenox, Ill.

PHILLIPS, MARION EDGAR (Jun. '33), With U. S. War Dept., Fort Riley (Res., 313 West 2d St., Junction City), Kans.

POPOFF, EGOR PAUL (Jun. '33), Mass. Inst., Tech. Dormitories, Cambridge, Mass.

POTTS, CLIFFORD BERNARD (Jun. '33), Insp., U. S. Bureau of Public Roads, Payson, Ariz.

RAMBONE, NICHOLAS ARTHUR (Jun. '33), 804 South Oak Drive, New York, N.Y.

RATHVON, SAMUEL FORNEY (Jun. '33), Route 4, Box 259, Anaheim, Calif.

ROACH, HAROLD (Jun. '33), 154 West 59th Pl., Los Angeles, Calif.

ROBARTS, KENNETH WILLIAM (Assoc. M. '33), Office and Designing Engr. for Alameda County Surv., 454 Fifth St., Oakland, Calif.

ROBISON, FRANK WILBUR (Jun. '33), Locating Engr., U. S. Forest Service, Glennville, Calif.

RONAN, EDWARD SANFORD, Jr. (Jun. '33), River St., Middleburgh, N.Y.

ROWE, ROBERT RICH (Assoc. M. '33), Gen. Constr. Supt., Pacific Coast Region, Montgomery Ward & Co., Constr. Dept., Oakland, Calif.

SACHSE, ALFRED JOHN (Jun. '33), Plummer, Idaho.

SANTORO, ALBERT PASQUAL (Jun. '33), 1650 Eighty-fourth St., Brooklyn, N.Y.

SCHARPER, WALTER ARTHUR (Jun. '33), 38 Prince St., Elizabeth, N.J.

SCHIFLETT, HUBERT LEE (Jun. '33), 1701 West Woodard St., Denison, Tex.

SCHOOLCRAFT, GEORGE BINGLEY (Jun. '33), 402 Central Life Bldg., Ottawa, Ill.

SCHWARTZ, PRESTON MACKELLAR (Jun. '33), 287 East Montecito Ave., Sierre Madre, Calif.

SCOTT, JOHN DEAL (Jun. '33), Box 302, Blacksburg, S.C.

SEIFERTH, SOLIS (M. '33), Archt. (Weiss, Dreyfous & Seiferth, Inc.), 600 Maison Blanche Bldg., New Orleans, La.

SMITH, NEWMANN BREEDEN (Assoc. M. '33), Asst. Engr., Met. Water Dist. of Southern California, 48 San Gorgonio Drive, Redlands, Calif.

SMYTH, SID (M. '33), Deputy State Highway Engr., State Highway Dept. (Res., 905 West Latham St.), Phoenix, Ariz.

SOLINS, DANIEL (Jun. '33), 3728 Poplar Ave., Brooklyn, N.Y.

SPICER, CHARLES BRYSON (Jun. '33), 4508 Saturn St., Los Angeles, Calif.

STINE, WILLIAM VIRGIL (Jun. '33), R. F. D. 1, Litchfield, Ohio.

SULLIVAN, EUGENE MICHAEL (Jun. '33), Eng. Insp., State Transit Comm., 270 Madison Ave., New York (Res., 527 One hundred and thirty-fourth St., Belle Harbor), N.Y.

SYLVESTER, JACK (Jun. '33), 105 E. South Mentor Ave., Pasadena, Calif.

TEAGUE, JAMES EDWARD (Jun. '33), Whitwell, Tenn.

TEPPT, RICHARD COMSTOCK (Jun. '33), New Berlin, N.Y.

TENCH, RUDOLPH CLAUDE (Jun. '33), Asst. Engr., Chf. Engr's. Office, C. & O. Ry., Richmond, Va.

THAYER, EARL EDWARD (Jun. '33), 703 Saginaw St., Durand, Mich.

THORNTON, WILLIAM CLINTON (Jun. '33), 315 Pearl St., Hartford, Conn.

TSATSOS, ALEXANDER GEORGE (Jun. '33), Asst. Supt., John Monks & Sons—Ulen & Co., Serres, Greece.

TUCKER, WILLIAM BURNS (Jun. '33), Bin K, Avenal, Calif.

TYBURSKI, LEO THADDEUS (Jun. '33), 285 South Washington St., Wilkes-Barre, Pa.

WALTON, EDWARD HAVILAND (Jun. '33), 115 Ogden Ave., Swarthmore, Pa.

WERNER, NILES (M. '33), Designer, Six Companies, Inc., Eng. Dept., Boulder City, Nev.

WICKES, ROBERT LINDSAY (Jun. '33), 140 Edgehill Rd., Syracuse, N.Y.

WIESNER, HENRY, Jr. (Jun. '33), 218 East 4th St., Weston, W. Va.

WINCHESTER, ERIC WILLIAM (Jun. '33), 337th Company, C.C.C., Camp S-139, Greentown, Pa.

WISSMILLER, IVAN LEE (Jun. '33), Carnegie Inst. of Technology, Schenley Park, Pittsburgh, Pa.

ZANDER, PAUL MARTIN (Jun. '33), E.C.W. Camp 68-PE, Metropolis, Ill.

MEMBERSHIP TRANSFERS

CONLON, WILLARD SYLVESTER (Assoc. M. '31; M. '33), City Engr. and Mgr. of Public Works Dept., Town Hall, Stamford, Conn.

CRADDOCK, FRANKLIN HARPER (Jun. '18; Assoc. M. '21; M. '33), Office Engr., State Dept. of Public Works (Res., 318 Nineteenth Ave.), Olympia, Wash.

DOCKSTADER, ERNEST AMBROSE (Assoc. M. '22; M. '33), Senior Structural Engr., Stone & Webster Eng. Corporation, 49 Federal St., Boston, Mass.

FLITTNER, FRANK WILLIAM (Jun. '21; Assoc. M. '23; M. '33), Associate Constr. Engr., U. S. Bureau of Public Roads, 802 Title and Trust Bldg., Phoenix, Ariz.

GREEN, HOWARD WHIPPLE (Jun. '18; Assoc. M. '23; M. '33), Secy., Cleveland Health Council, 1900 Euclid Ave., Cleveland, Ohio.

LAWLOR, JOSEPH PATRICK (Assoc. M. '24; M. '33), Vice-Pres. and Gen. Mgr., Layne North Central Co., 1421 South Circle Ave., Forest Park, Ill. (Res., 622 Brookridge, Ames, Iowa.)

PONSY, KARL WILLIAM (Jun. '25; Assoc. M. '33), Asst. Chf. Draftsman, Truscon Steel Co., (Res., 279 Redondo Rd.), Youngstown, Ohio.

POPE, LATHROP CARLETON (Assoc. M. '25; M. '33), Res. Engr., The Carleton Co., Inc., 10 Brooklyn Ave., Brooklyn (Res., 46-34 One hundred and fifty-eighth St., Flushing), N.Y.

ROACH, JAMES HOWARD (Assoc. M. '10; M. '33), Chf. Valuation Engr., N.Y.C. Lines, 466 Lexington Ave., Room 800, New York, N.Y.

ROUSCULP, JOHN ALLEN (Jun. '28; Assoc. M. '33), Senior Designing Engr., Div. of Eng., City of Columbus (Res., 320 East Tulane Rd.), Columbus, Ohio.

SHIELDS, JAMES RALPH (Jun. '12; Assoc. M. '17; M. '33), Bldg. Insp., City of Sacramento (Res., 1308 Thirty-fifth St.), Sacramento, Calif.

WRIGHT, WILLIAM THEODORE (Jun. '28; Assoc. M. '33), Structural Engr., T. C. Kistner & Co., 814 Architects Bldg., Los Angeles (Res., 820 North Martel Ave., Hollywood), Calif.

REINSTATEMENTS

STEELE, ROBERT MCARA, Assoc. M., reinstated Dec. 6, 1933.

RESIGNATIONS

BAILEY, ROBERT WILLIAM, Jr., Assoc. M., resigned Dec. 4, 1933.

CLAFLIN, WILLIAM BEMENT, M., resigned Dec. 4, 1933.

HEYSER, ESTILL SAMUEL, Assoc. M., resigned Nov. 23, 1933.

HICKMAN, PAUL, Jun., resigned Dec. 5, 1933.

JIMENEZ, JULIO, Jun., resigned Dec. 4, 1933.

KOSOWSKY, JACK LEE, Jun., resigned Dec. 4, 1933.

LOVE, JOSEPH WARNER EDWARDS, M., resigned Dec. 6, 1933.

LYNN, CHARLES FERGUSON, Jun., resigned Dec. 5, 1933.

PILAND, JULIUS LYNCH, Assoc. M., resigned Dec. 4, 1933.

REILLY, THOMAS GEORGE, Assoc. M., resigned Nov. 10, 1933.

SANDBECK, HANS CHRISTIAN, Assoc. M., resigned Nov. 9, 1933.

WACHTMEISTER, HANS GOTTHARD, M., resigned Nov. 22, 1933.

YOUNG, HERMAN STONE, Jun., resigned Nov. 15, 1933.

DEATHS

BOTT, JOHN B. Elected M., Oct. 1, 1890; died Dec. 3, 1933.

BRAND, THEODORE. Elected Jun., Oct. 26, 1931; died Nov. 5, 1933.

BRUCH, FRED WILLIAMS. Elected M., April 4, 1900; date of death unknown.

BYERS, MORTON LEWIS. Elected Jun., Jan. 2, 1890; M., Sept. 7, 1898; died Nov. 22, 1933.

CLARK, CHARLES HOMER. Elected M., April 16, 1918; date of death unknown.

COTTMAN, LEWIS WARRINGTON. Elected M., April 30, 1912; died Nov. 4, 1933.

DUNHAM, HERBERT FRANKLIN. Elected M., Oct. 1, 1890; died Dec. 1, 1933.

DURHAM, LEICESTER. Elected M., May 7, 1913; died Nov. 21, 1933.

FINCH, FRANK HAMILTON. Elected Assoc. M., Nov. 28, 1916; died Sept. 5, 1933.

FRY, ALFRED BROOKS. Elected M., Dec. 6, 1910; died Dec. 4, 1933.

GARGES, SAMUEL JOSEPH. Elected Affiliate, April 19, 1920; date of death unknown.

HATTON, THOMAS CHALKLEY. Elected M., Mar. 6, 1895; died Nov. 11, 1933.

HEWETT, BERTRAM HENRY MAJENDIE. Elected Assoc. M., Apr. 5, 1905; M., Oct. 1, 1907; died Nov. 14, 1933.

HOYT, WARREN ALBERT. Elected M., June 30, 1910; date of death unknown.

HUNTER, ADAM. Elected Assoc. M., Sept. 6, 1905 M., May 2, 1911; died Nov. 1, 1933.

KING, THOMAS HENRY. Elected Assoc. M., June 19, 1922; M., Oct. 1, 1926; died Nov. 8, 1933.

NAGLER, FLOYD AUGUST. Elected Jun., Mar. 14, 1916; Assoc. M., May 13, 1918; M., July 12, 1926; died Nov. 10, 1933.

NORBERG, ALFRED. Elected Assoc. M., Jan. 15, 1923; died Nov. 15, 1933.

ROGERS, CLARENCE MORD. Elected M., Jan. 6, 1915; died October 1933.

SMITH, ACHESON. Elected M., Jan. 13, 1919; died July 12, 1933.

SPRING, SIR FRANCIS JOSEPH EDWARD. Elected M., Jan. 3, 1894; died August 1933.

STEVENS, LEIGH E. Elected Assoc. M., Feb. 6, 1912; died Nov. 5, 1933.

STRUCKMANN, HOLGER. Elected Assoc. M., Nov. 30, 1909; M., May 7, 1913; died Nov. 17, 1933.

SYME, GEORGE FREDERICK. Elected M., Mar. 12, 1923; died Nov. 27, 1933.

TOTAL MEMBERSHIP AS OF DECEMBER 9, 1933

Members	5,763
Associate Members	6,271
Corporate Members	12,034
Honorary Members	18
Juniors	3,017
Affiliates	111
Fellows	5
Total	15,18

Men Available

These items are from information furnished by the Engineering Societies Employment Service, with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fee is to be found on page 97 of the 1933 Year Book of the Society. To expedite publication, notices should be sent direct to the Employment Service, 31 West 39th Street, New York, N.Y. Employers should address replies to the key number, care of the New York Office, unless the word Chicago or San Francisco follows the key number, when the reply should be sent to the office designated.

CONSTRUCTION

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; graduate C.E.; 29; married; 9 years experience with one firm of general contracting builders and engineers; all types of building construction. Experienced in estimating, construction analyses, drafting, design, office routine, supervision of construction in field, surveying, and layout work In responsible charge for several years. D-2712.

COST ENGINEER-CONSTRUCTION; Jun. Am. Soc. C.E.; 29; 5½ years on subsurface construction-materials, steel erection, time studies, cost analysis, and estimating on subway work and cofferdam. D-2151.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 31; single; B.S. in C.E., University of Illinois, 1933; 1 year surveying, rodman; 3 years land surveying, rodman to chief of party; 3 years railroad construction and maintenance, rodman to instrumentman in charge of party. Available immediately. Will go anywhere. D-2704.

DESIGN

STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; 38; married; graduate; state licenses; 10 years experience, surveying, design, and construction. Design, detail, and preparation of plans and specifications, on railroad, highway, parkway, harbor, and tall-building structures. Completely familiar with the design of rigid-frame bridges. Available immediately. D-1496.

CIVIL AND STRUCTURAL ENGINEER; Jun. Am. Soc. C.E.; 29; B.S. in C.E. and C.E. degrees; about 5 years experience in New York City as a designer, detailer, draftsman, checker, and estimator of steel and reinforced concrete. References and samples of work sent on request. C-6186.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 45; with 25 years experience in structural and mechanical lines, including the design, checking, and detailing of structural steel for office, apartment, and mill buildings, and the design, detail, and construction of coal and ash-handling plants and equipment. Location, New York or vicinity. A-3807.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 32; married; New Jersey structural license; B.S. in C.E.; 12½ years structural experience, designing and detailing concrete and steel railroad and highway bridges; flat-slab, steel, and timber industrial buildings, and reinforced concrete dams. Desires field or office position. Location immaterial. D-1976.

EXECUTIVE

GRADUATE STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; over 20 years experience in the design and construction of buildings of all types; desires position in engineer's, architect's, or contractor's office. Experienced in the preparation of estimates and specifications for buildings, piers, etc. Competent steel and concrete designer. B-5187.

ENGINEERING EXECUTIVE - REPRESENTATIVE; M. Am. Soc. C.E.; registered, Pennsylvania; 30 years experience—15 of them as chief engineer; wide knowledge of construction, both field and office; seeks connection with reputable firm wishing sales or investigating representative in Mexico or South America; 7 years residence in Mexico; knowledge of Spanish-Latin-American requirements, customs, trade practices, etc. B-7058.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; Sigma Xi; 27; graduate of Worcester Polytechnic Institute, 1927; 10 months detail draftsman; 18 months assistant engineer on erection of suspension bridge; 2 months design; 2 years job engineer, contact and promotional work with general contractor. Desires connection with contractor or consulting engineer. Available immediately. Location immaterial. D-2691.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 37; married; graduate of Massachusetts Institute of Technology. Experienced structural-steel erection, office buildings, apartment houses, bridges, viaducts, etc.; loading, unloading, and yard storage; fabricating-shop practice; field engineering; erection estimating; costs. Desires executive field or office position. Vicinity of New York preferred. Available immediately. C-2210.

CIVIL ENGINEER; M. Am. Soc. C.E.; college graduate; 30 years experience in general contract work on tunnels, intakes, docks, piers, piersheds, power plants, foundations, caissons, bridges, sea walls, concrete and steel buildings, incinerators, sewage-disposal plants, roads, and dams; desires employment. Has served as engineer, superintendent, manager, and executive. D-2695.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 41; married; graduate, B.S. in C.E.; New York State licensed professional engineer; 11 years experience as surveyor, inspector, estimator, assistant engineer, and superintendent on building and heavy construction; 10 years engineer and contractor, own business on building construction, bulk gasoline plants, alterations. Location, New York City. Available immediately. B-2044.

CIVIL ENGINEER; M. Am. Soc. C.E.; married; graduate of Rensselaer Polytechnic Institute; licensed engineer, states of New York and New Jersey; desires position as inspector of buildings or on reports concerning the same; 25 years superintendent of building construction; major operations, including mechanical and other equipment; daily and weekly reports and charts; inspection at shop and field; also research work. D-1756.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 19 years experience in sanitary and municipal work, embracing design and construction of sewerage systems, including treatment works, water-supply systems, streets and pavements, preliminary investigations, and reports. Technical graduate. Married. Seeks connection with consulting engineering or with contracting firm. A-466.

ENGINEER; M. Am. Soc. C.E.; New York State license; familiar with brewery design and construction through surveys, reports, and inspections for underwriters. Man of vision, imagination, and creative ability. Experience in cost analysis with training in business finance and sales engineering. A-1343.

STRUCTURAL ENGINEER EXECUTIVE; M. Am. Soc. C.E.; 45; married. Over 20 years general business experience in steel fabricating and contracting, particularly in estimating, designing, and sales. Also efficient organization rebuilding. Excellent references. C-5095.

JUNIOR

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 26; single; B.S. in Civil Engineering, Duke University, 1933. Majored in structural steel design and water supply; 3 years experience as inspector on telephone apparatus. Desires opportunity in any branch of civil engineering. Location immaterial. Available immediately. D-2683-4750—Chicago.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 27; single; B.S. in C.E., Rutgers University, 1930; 1 3/4 years transitman, Essex County (New Jersey) Highway Department; on many civil service lists; good mathematician. Wants work in any branch of engineering. Will teach in high school or college. D-663.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; Cornell University, C.E.; 26; single; 5 years with general contractor as field engineer and assistant superintendent in charge of subway, sewer, pipe, and utility lines, building construction. Good office man on estimates, design, drafting. Best references. Location anywhere. Salary open. C-6070.

CIVIL ENGINEER; Student Member; B.S. in C.E., 1932; 7 years city and land surveying, field and office. D-2477.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 27; single; C.E. degree, Columbia University, 1930; 2 1/2 years experience as assistant engineer with general contractor; design, estimating, supervision of construction, deck and harbor work, foundations, heavy construction. Good mathematician; capable and reliable draftsman and designer. Desires engineering position of any nature. D-2682.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; Columbia University, 1931; 24; single. Has had varied surveying experience; also junior estimating. Capable; dependable. Desires position in any branch of civil engineering, field or office. Available immediately. Salary secondary. Location immaterial, but East preferred. D-2662.

SALES

BUSINESS GETTER; Assoc. M. Am. Soc. C.E.; having persuasive contacts with a particular class of colleges, schools, and hospitals is open for engagement by large firm having a meritorious product. Commission with drawing account. B-9276.

TEACHING

CIVIL ENGINEER; M. Am. Soc. C.E.; S.P.E.E.; registered professional engineer; 40; married; degrees, B.C.E., M.S., and C.E.; 6 years practical experience; 14 years teaching in engineering drawing, applied mechanics, and civil engineering departments; also administrative work; excellent teacher, now employed; desires to change location. D-2687.

ENGINEER; Jun. Am. Soc. C.E.; Massachusetts Institute of Technology graduate in civil engineering; single; 4 years experience teaching differential and integral calculus, and 6 years experience in all phases of building industry. Desires full-time teaching position or fellowship in mathematics or civil engineering. Location immaterial. C-3262.

RECENT BOOKS

New books of interest to Civil Engineers, donated by the publishers to the Engineering Societies Library, or to the Society's Reading Room, will be found listed here. A comprehensive statement regarding the service which the Library makes available to members is to be found on page 87 of the Year Book for 1933. These notes regarding the books are taken from the books themselves, and this Society is not responsible for them.

ARMY ENGINEERING. By W. A. Mitchell. 3 ed. Washington, D.C., Society of American Military Engineers, 1933. 329 pp., illus., diagrs., tables, 7 × 4 in., leather, $3.

This handbook covers the knowledge of engineering required of officers in the U. S. Army and is a revision of the course given in the First Class at the U.S. Military Academy. Mapping, shelters, roads, railways, bridges, fortification, camouflage, explosives, demolitions, siege works, chemical warfare, gasoline engines, power plants, seacoast defenses, and river and harbor works are discussed from the military viewpoint.

DER BETONSTRASSENBAU. (Sammlung Göschen (976). By W. Petry. Berlin and Leipzig, Walter de Gruyter and Co., 1933. 124 pp., illus., tables, 6 × 4 in., cloth, 1.62 rm.

A concise review of progress in concrete road building, especially in Germany. Road-building machinery is described, and details are given concerning many varieties of construction. A table gives data on modern German concrete roads.

DREI KLASSIKER DER STRÖMUNGSLEHRE. (Ostwald's Klassiker der exakten Wissenschaften, Nr. 237). By Hagen, Poiseuille and Hagenbach; ed. by L. Schiller. Leipzig, Akademische Verlagsgesellschaft, 1933. 97 pp., diagrs., tables, 8 × 5 in., cloth, 5.60 rm.

In 1843, a commission appointed by the Académie des Sciences reported upon Poiseuille's discovery of the law governing flow in small pipes, which discovery however had been anticipated in a paper by G. Hagen, published in 1839. In 1860, E. Hagenbach published an account of his studies on viscosity, the first completely correct solution of the problem of viscosity to appear. These three papers are here republished, with biographic and explanatory notes.

ENTWURF UND AUSFÜHRUNG VON STAU- UND KANALDÄMMEN AUS ERDE UND FELS. By O. Walch. Berlin, J. Springer, 1933. 234 pp., illus., diagrs., charts, tables, 9 × 6 in., cloth, 22.50 rm.

A review of modern practice in the construction of earth dams. Special consideration is given to the necessary preliminary investigations at the site and in the laboratory. Construction equipment and methods are discussed in detail. A useful feature is the tables, giving the principal data about many existing dams.

EXPERIMENTAL WORK ON ROADS. Report for the Year 1932 of the Technical Advisory Committee on Experimental Work. Great Britain, Ministry of Transport, Roads Department, London, 1933. 75 pp., charts, tables, 10 × 6 in., paper, 1s. 6d.

During 1932, the experimental work of the committee has comprised studies of the comparative worth of various methods of constructing concrete roads, tests of road surface dressings, and studies of tar and bituminous surfaces. In addition, research work upon wheel impact and the deflection of concrete road slabs has been carried on in the laboratory. This report presents the progress of the year in these studies.

"HÜTTE" DES INGENIEURS TASCHENBUCH, Bd. 3. LIEFERUNG 1. Edited by Akademischer Verein Hütte. 26 ed. Berlin, Wilhelm Ernst and Sohn, 1933. 676 pp., diagrs., charts, tables, 8 × 5 in., paper, 10 rm.

Volume 3 of "Hütte" is devoted to civil engineering. The twenty-sixth edition will appear in two parts, of which the first is now on sale. It treats of statics of construction, foundations, earthwork, tunneling, reinforced concrete, framed structures, heating, ventilation, factory buildings, hydraulic works, water supply, and sewerage. Each subject has been thoroughly revised.

MAPS AND SURVEY. By A. R. Hinks. 3 ed. Cambridge (England), University Press; New York and Toronto, Macmillan Co., 1933. 283 pp., illus., diagrs., charts, tables, 9 × 6 in., cloth, $4.25.

An introduction to the whole subject of map-making, both in the field and in the office. Starting with a brief history of early maps, the author proceeds to a discussion of the making of modern maps. The latter half of the book describes the methods of work and the instruments used in exploratory and trigonometric surveys, in surveys for land settlement, and in geodetic and photographic surveying. The book is an eminently readable account of the present state of surveying and cartography.

PRACTICAL ACOUSTICS FOR THE CONSTRUCTOR. By C. W. Glover. London, Chapman and Hall, 1933. 408 pp., illus., diagrs., charts, tables, 9 × 6 in., cloth, 25s.

The architect or engineer in search of practical information on acoustics will find this a helpful book. The theory of acoustics is presented clearly, and its application to the design of buildings is illustrated. Sound insulation, the reduction of noise and vibration, the use of sound absorbents, and aircraft noise are discussed. Typical specifications for acoustical work are given. Appendixes include a useful bibliography, tables of acoustical coefficients for 700 materials, and particulars of many representative materials for damping sound and vibration.

SAFETY AND ECONOMY IN HEAVY CONSTRUCTION. By R. J. Reigeluth. New York and London, McGraw-Hill Book Co., 1933. 237 pp., illus., diagrs., tables, 8 × 5 in., leather, $2.50.

The purpose of this handbook is to give superintendents and foremen definite information about the strength of construction materials and the capacity and maintenance of construction equipment. The setting and operation of portable boilers; the proper use of rigging, derricks, and cranes; excavating and pile driving; the use of explosives; and other matters pertaining to construction work are discussed clearly and practically, with emphasis upon safety.

VOCATIONAL GUIDANCE IN ENGINEERING LINES. Edited by American Association of Engineers. Easton, Pa., Mack Printing Co., 1933. 521 pp., illus., charts, 9 × 6 in., cloth, $2.50.

The aim of this book is to be "a simple, practical yardstick by which those young men who aspire to be engineers can measure their natural fitness for the tasks imposed by the profession." Chapters upon every important branch and specialty of engineering, each by a well-known practitioner, give an unusually accurate and complete picture of the whole field. In addition, such general subjects as engineering ethics, idealism in engineering, vocational guidance, and aptitude tests are discussed.